

INSECTS OF HAWAII

*To Harold St. John,  
with best wishes,  
Elwood C. Zimmerman*



#31 job.

# INSECTS OF HAWAII

*A Manual of the Insects of the Hawaiian Islands, including an Enumeration of the Species and Notes on their Origin, Distribution, Hosts, Parasites, etc.*

by **ELWOOD C. ZIMMERMAN**

Associate Entomologist, Experiment Station,  
Hawaiian Sugar Planters' Association; Curator  
of Entomology, Bernice P. Bishop Museum

VOLUME 2

APTERYGOTA TO THYSANOPTERA

INCLUSIVE

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## PREFACE TO VOLUME 2

This is the second volume of the series, *Insects of Hawaii*. It records 371 insects in the orders from the primitive Thysanura through the Thysanoptera. Some of the groups included are known inadequately, and the treatment given them here is considered preliminary. A brief survey of the text will reveal how much is yet to be done.

Reference should be made to the "Preface to the First Five Volumes" in Volume 1 for detailed discussion of this series of volumes and for general acknowledgments. In addition to those persons whose aid has been acknowledged in Volume 1, the following have contributed to this volume: The manuscript for the orders of the Apterygota was read by Harlow B. Mills, Illinois Natural History Survey; that for the Orthoptera, Dermaptera, Zoraptera and Corrodentia by A. B. Gurney, Division of Insect Identification, U. S. Bureau of Entomology and Plant Quarantine; A. E. Emerson, University of Chicago, E. M. Miller, University of Miami, and J. S. Rosa, Experiment Station, H. S. P. A., read the text on the Isoptera; J. V. Pearman, England, sent numerous notes and answered many questions pertaining to the Corrodentia; the section on Mallophaga was read by Miss Theresa Clay, England, and E. W. Stafford, Mississippi State College; J. G. Needham, Cornell University, and F. X. Williams, Experiment Station, H. S. P. A., read the Odonata text; the section on the Thysanoptera was read by F. A. Bianchi, Experiment Station, H. S. P. A., and K. Sakimura, Pineapple Research Institute, Honolulu. R. H. Van Zwaluwenburg, Experiment Station, H. S. P. A., read the entire volume in original manuscript and in proof. The illustrations for this volume, as for the other four volumes in this series, were made mostly by Frieda Abernathy, University of California; Arthur Smith, British Museum (Natural History); and W. Twigg-Smith and J. T. Yamamoto, Experiment Station, H. S. P. A. These persons have done much to make these pages more complete and accurate, and my indebtedness to each of them is great.

E.C.Z.

*Honolulu, Hawaii*  
*July, 1948*

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# CHECKLIST OF THE INSECTS IN THIS VOLUME

## Subclass **APTERYGOTA**

### Order **THYSANURA**

#### Family **MACHILIDAE**

##### Subfamily **MEINERTELLINAE**

Genus **MACHILOIDES** Silvestri  
    **heteropus** (Silvestri)  
    **perkinsi** (Silvestri)

#### Family **LEPISMATIDAE**

##### Subfamily **LEPISMATINAE**

Genus **ACROTELSELLA** Silvestri  
    **collaris** (Fabricius)  
    **hawaiiensis** (Silvestri)

Genus **CTENOLEPISMA** Escherich  
    **urbana** Slabaugh

##### Subfamily **NICOLETHINAE**

Genus **NICOLETIA** Gervais  
    Subgenus **Anelpistina** Silvestri  
        **meinerti** Silvestri

(Two species in two genera not identified.)

### Order **DIPLURA**

#### Family **CAMPODEIDAE**

Genus **PLUSIOCAMPA** Silvestri  
    Subgenus **Microcampa** Silvestri  
        **perkinsi** Silvestri

Genus **LEPIDOCAMPA** Oudemans  
    **giffardii** Silvestri

## Family JAPYGIDAE

## Subfamily PARAJAPYGINAE

Genus **PARAJAPYX** Silvestri  
*isabellae* (Grassi)

## Subfamily JAPYGINAE

Genus **JAPYX** (Haliday)  
*sharp*i Silvestri

## Order PROTURA

Species not identified

## Order COLLEMBOLA

## Suborder ARTHROPLEONA

## Superfamily PODUROIDEA

## Family ACHORUTIDAE

## Subfamily ACHORUTINAE

Genus **ACHORUTES** Templeton  
Subgenus *Schöttella* Schaeffer  
*alba* (Folsom)

Genus **XENYLLA** Tullberg  
*alba* Folsom  
*sensilis* Folsom

## Subfamily NEANURINAE

## Tribe PSEUDACHORUTINI

Genus **STACHIA** Folsom  
*minuta* Folsom

## Tribe NEANURINI

Genus **PROTANURA** Börner  
*capitata* Folsom

Genus **NEANURA** MacGillivray  
*citronella* Carpenter



## Family ONYCHIURIDAE

## Subfamily ONYCHIURINAE

Genus **ONYCHIURUS** Gervais  
*finetarius* (Linnaeus)

## Subfamily TULLBERGINAE

Genus **TULLBERGIA** Lubbock  
*silvicola* Folsom

## Superfamily ENTOMOBRYOIDEA

## Family ISOTOMIDAE

## Subfamily ISOTOMINAE

Genus **FOLSOMIDES** Stach  
*exiguus* Folsom

Genus **ISOTOMODES** Axelson  
*denisi* Folsom

Genus **FOLSOMIA** Willem  
*finetaria* (Linnaeus)

Genus **DENISIA** Folsom  
*falcata* Folsom

Genus **PROISOTOMA** Börner  
*nigromaculosa* Folsom

Genus **ISOTOMURUS** Börner  
*palustris balteatus* (Reuter)

Genus **ISOTOMA** Bourlet  
*minor* Schaeffer  
*perkinsi* Carpenter

## Family ENTOMOBRYIDAE

## Subfamily ENTOMOBRYINAE

## Tribe ENTOMOBRYINI

Genus **SINELLA** Brook  
*caeca* (Schött)

Genus **SIRA** Lubbock  
*jacobsoni* Börner

Genus **ENTOMOBRYA** Rondani  
*insularis* Carpenter

*kalakaua* Carpenter  
*lactea* Folsom  
*multifasciata imminuta* Folsom

Genus **LEPIDOCYRTUS** Bourlet  
*cyaneus* Tullberg  
*heterophthalmus* Carpenter  
*immaculatus* Folsom  
*inornatus* Folsom

Genus **DREPANOCYRTUS** Handschin  
*terrestris* Folsom

Subfamily PARONELLINAE

Tribe PARONELLINI

Genus **SALINA** MacGillivray  
*maculata* Folsom

Subfamily CYPHODERINAE

Tribe CYPHODERINI

Genus **CYPHODERUS** Nicolet  
*assimilis* Börner

Suborder SYMPHYPLEONA

Family SMINTHURIDAE

Subfamily SMINTHURIDINAE

Tribe SMINTHURIDINI

Genus **SMINTHURIDES** Börner  
Subgenus *Denisiella* Folsom and Mills  
*ramosus* (Folsom)

Subfamily SMINTHURINAE

Tribe BOURLETIELLINI

Genus **BOURLETIELLA** Banks  
*insula* Folsom

Subfamily DICYRTOMINAE

Genus **PTENOTHRIX** Börner  
*dubia* Folsom

Subclass **PTERYGOTA**Division **EXOPTERYGOTA**Order **ORTHOPTERA**Suborder **CURSORIA**Family **BLATTIDAE**Subfamily **ECTOBIINAE**

Genus **ALLACTA** Saussure and Zehntner  
*similis* (Saussure)

Genus **GRAPTOBLATTA** Hebard  
*notulata* (Stål)

Subfamily **PSEUDOMOPINAE**

Genus **BLATTELLA** Caudell  
*germanica* (Linnaeus)  
*lituricollis* (Walker)

Genus **SYMPLOCE** Hebard  
*hospes* (Perkins)

Genus **SUPELLA** Shelford  
*supellectilium* (Serville)

Genus **LOBOPTERA** Brunner  
*dimidiatipes* (Bolivar)

Subfamily **BLATTINAE**

Genus **CUTILIA** Stål  
*soror* (Brunner)

Genus **NEOSTYLOPYGA** Shelford  
*rhombifolia* (Stoll)

Genus **PERIPLANETA** Burmeister  
*americana* (Linnaeus)  
*australasiae* (Fabricius)  
*brunnea* Burmeister

## Subfamily PANCHLORINAE

Genus **LEUCOPHAEA** Brunner  
*maderaë* (Fabricius)

Genus **NAUPHOETA** Burmeister  
*cinerea* (Olivier)

Genus **PYCNOSELUS** Scudder  
*surinamensis* (Linnaeus)

Genus **DIPLOPTERA** Saussure  
*dytiscoides* (Serville)

## Subfamily CORYDIINAE

Genus **EUTHYRRHAPHA** Burmeister  
*pacifica* (Coquebert)

Genus **HOLOCOMPSA** Burmeister  
*fulva* (Burmeister)

## Suborder GRESSORIA

## Family MANTIDAE

## Subfamily EREMIAPHILINAE

Genus **ORTHODERA** Burmeister  
*ministralis* (Fabricius)

## Subfamily MANTINAE

Genus **TENODERA** Burmeister  
*angustipennis* Saussure

Genus **HIERODULA** Burmeister  
*patellifera* (Serville)

## Suborder SALTATORIA

## Family ACRIDIDAE

## Subfamily PYRGOMORPHINAE

Genus **ATRACTOMORPHA** Saussure  
*ambigua* Bolivar

## Subfamily CYRTACANTHACRIDINAE

Genus **OXYA** Serville  
**chinensis** (Thunberg)

Genus **PARAIDEMONA** Brunner  
**mimica** Scudder

## Family TETTIGONIIDAE

## Subfamily PHANEROPTERINAE

Genus **ELIMAEA** Stål  
**punctifera** (Walker)

Genus **HOLOCHLORA** Stål  
**japonica** Brunner

## Subfamily COPIPHORINAE

Genus **CONOCEPHALOIDES** Perkins  
**remotus** (Walker)

Genus **BANZA** Walker  
**affinis** (Perkins)  
**brunnea** (Perkins)  
**deplanata** (Brunner)  
**kauaiensis** (Perkins)  
**mauiensis** (Perkins)  
**molokaiensis** (Perkins)  
**nihoa** Hebard  
**nitida nitida** (Brunner)  
**nitida crassipes** (Perkins)  
**parvula** (Walker)  
**unica** (Perkins)

## Subfamily CONOCEPHALINAE

Genus **CONOCEPHALUS** Thunberg  
**saltator** (Saussure)

## Subfamily LISTROSCELINAE

Genus **XIPHIDIOPSIS** Redtenbacher  
**lita** Hebard

## Family GRYLLIDAE

## Subfamily GRYLLOTALPINAE

Genus **GRYLLOTALPA** Latreille  
*africana* Palisot de Beauvois

Subfamily **GRYLLINAE**

Genus **GRYLLODES** Saussure  
*sigillatus* (Walker)

Genus **ACHETA** (Linnaeus)  
*conspersa* (Schaum)  
*oceanica* (LeGuillou)

Subfamily **MYRMECOPHILINAE**

Genus **MYRMECOPHILA** Latreille  
*americana* Saussure  
*quadrispina* Perkins

Subfamily **MOGOPLISTINAE**

Genus **CYCLOPTILUM** Scudder  
*bimaculatum* (Shiraki)

Genus **CYCLOPTILOIDES** Sjöstedt  
*americanus* (Saussure)

Subfamily **TRIGONIDIINAE**

Genus **PARATRIGONIDIUM** Brunner  
*atroferrugineum* Brunner  
*attenuatum* Perkins  
*crepitans* Perkins  
*debile* Perkins  
*exiguum* Perkins  
*filicum* Perkins  
*freycinetiae* Perkins  
*grande* Perkins  
*molokaiense* Perkins  
*pacificum* Scudder  
*robustum* Perkins  
*roseum* Perkins  
*saltator* Perkins  
*subroseum* Perkins  
*varians* Perkins  
*viridescens* Perkins

Genus **METIOCHE** Stål  
*vittaticollis* (Stål)

## Subfamily ENEOPTERINAE

## Tribe PROGNATHOGRYLLINI

Genus **PROGNATHOGRYLLUS** Brunner

*alatus* Brunner  
*elongatus* Perkins  
*inexpectatus* Perkins  
*oahuensis* Perkins  
*robustus* Perkins

Genus **LEPTOGRYLLUS** Perkins

*apicalis* Perkins  
*cylindricus* Perkins  
*deceptor* Perkins  
*elongatus* Perkins  
*forficularis* (Brunner)  
*fusconotatus* Perkins  
*kauaiensis* Perkins  
*nigrolineatus* Perkins  
*nigromaculatus* Perkins  
*similis* Perkins  
*simillimus* Perkins

Genus **THAUMATOGRYLLUS** Perkins

*variegatus* Perkins

Order **ISOPTERA**

## Family KALOTERMITIDAE

Genus **CRYPTOTERMES** Banks

*brevis* (Walker)

Genus **KALOTERMES** Hagen

*immigrans* Snyder

Genus **NEOTERMES** Holmgren

*connexus* Snyder

## Family RHINOTERMITIDAE

Genus **COPTOTERMES** Wasmann

*formosanus* Shiraki

Order **EMBIOPTERA**Suborder **EUEMBIOPTERA**Family **OLIGOTOMIDAE**

Genus **OLIGOTOMA** Westwood  
**saundersii** (Westwood)

Order **DERMAPTERA**Suborder **FORFICULINA**Family **LABIDURIDAE**Subfamily **PSALINAE**

Genus **ANISOLABIS** Fieber  
**eteronoma** Borelli  
**perkinsi** Burr

Genus **EUBORELLIA** Burr  
**annulipes** (Lucas)

Subfamily **LABIDURINAE**

Genus **LABIDURA** Leach  
**riparia** (Pallas)

Family **LABIIDAE**Subfamily **LABIINAE**

Genus **PROLABIA** Burr  
**arachidis** (Yersin)

Genus **LABIA** Leach  
**curvicauda** (Motschulsky)  
**dubronyi** Hebard  
**pilicornis** (Motschulsky)

Genus **SPHINGOLABIS** Bormans  
**hawaiiensis** (Bormans)



## Family CHELISOCHIDAE

## Subfamily CHELISOCHINAE

Genus **CHELISOCHES** Scudder  
**morio** (Fabricius)

Genus **SPARATTINA** Verhoeff  
**nigrorufa** (Burr)

## Order ZORAPTERA

## Family ZOROTYPIDAE

Genus **ZOROTYPUS** Silvestri  
**swezeyi** Caudell

## Order CORRODENTIA

## Family PERIENTOMIDAE

Genus **LEPIDOPSOCUS** Enderlein  
**costalis** (Banks)  
**marmoratus** (Banks)  
**unicolor** (Banks)

Genus **CYPTOPHANIA** Banks  
**hirsuta** Banks

## Family PSOQUILLIDAE

Genus **PSOQUILLA** Hagen  
**marginipunctata** Hagen

## Family LIPOSCELIDAE

Genus **LIPOSCELIS** Motschulsky  
**divinatorius** (Müller)

## Family PACHYTROCTIDAE

Genus **PSYLLONEURA** Enderlein  
**williamsi** Banks

## Family PSOCATHROPIDAE

Genus **PSYLLIPSOCUS** Selys  
**minutissimus** (Enderlein)

Genus **PSOCATHROPOS** Ribaga  
    *lachlani* Ribaga

Family CAECILIIDAE

Genus **CAECILIUS** Curtis  
    *analis* Banks

Genus **HAGENIOLA** Banks  
    *solitaria* Banks

Family PERIPSOCIDAE

Genus **CHAETOPSOCUS** Pearman  
    *richardsi* Pearman

Genus **ECTOPSOCUS** McLachlan  
    *fullawayi* Enderlein  
    *hawaiiensis* Enderlein  
    *perkinsi* Banks

Family HEMIPSOCIDAE

Genus **HEMIPSOCUS** Selys  
    *roseus* (Hagen)

Family ELIPSOCIDAE

Genus **KILAUELLA** Enderlein  
    *criniger* (Perkins)  
    *debilis* (Perkins)  
    *erythrosticta* (Perkins)  
    *frigida* (Perkins)  
    *inaequifusca* (Perkins)  
    *micramaura* (Perkins)  
    *psylloides* (Perkins)  
    *vinosa* (McLachlan)

Genus **PALISTREPTUS** Enderlein  
    *inconstans* (Perkins)  
    *montanus* (Perkins)

Family PSOCIDAE

Genus **PSOCUS** Fabricius  
    *distinguendus* Perkins

**haleakalae** Perkins  
**heterogamias** Perkins  
**hualalai** Perkins  
**kauaiensis** Perkins  
**konae** Perkins  
**lanaiensis** Perkins  
**molokaiensis** Perkins  
**monticola** Perkins  
**oahuensis** Perkins  
**simulator** Perkins  
**sylvestris** Perkins  
**unicus** Perkins  
**vittipennis** Perkins

## Order MALLOPHAGA

### Series AMBLYCERA

#### Family GYROPIDAE

##### Subfamily GYROPINAE

Genus **GYROPUS** Nitzsch  
**ovalis** Nitzsch

##### Subfamily GLIRICOLINAE

Genus **GLIRICOLA** Mjoeberg  
**porcelli** (Linnaeus)

#### Family BOOPIIDAE

##### Subfamily BOOPIINAE

Genus **HETERODOXUS** Le Souëf and Bullen  
**spiniger** (Enderlein)

#### Family MENOPONIDAE

##### Subfamily MENOPONINAE

Genus **EOMENACANTHUS** Uchida  
**stramineus** (Nitzsch)

Genus **MENOPON** Nitzsch  
**gallinae** (Linnaeus)  
**phaeostomum** Nitzsch

Genus **MYRSIDEA** Waterston  
    *conspicua* (Kellogg and Chapman)  
    *cryptostigma* (Kellogg and Chapman)  
    *invadens* (Kellogg and Chapman)

Genus **MACHAERILAEMUS** Harrison  
    *hawaiiensis* (Kellogg and Chapman)

Genus **COLPOCEPHALUM** Nitzsch  
    *brachysomum* Kellogg and Chapman  
    *discrepans* Kellogg and Chapman  
    *hilensis* (Kellogg and Chapman)  
    *turbinatum* Denny

Genus **ACTORNITHOPHILUS** Ferris  
    *epiphanes* (Kellogg and Chapman)  
    *kilauensis* (Kellogg and Chapman)

Subfamily ANCISTRONINAE

Genus **ANCISTRONA** Westwood  
    *vagelli* (Fabricius)

Series ISCHNOCERA

Family TRICHODECTIDAE

Genus **TRICHODECTES** Nitzsch  
    *canis* (Degeer)

Genus **BOVICOLA** Ewing  
    *bovis* (Linnaeus)  
    *caprae* (Gurtl)  
    *equi* (Linnaeus)  
    *ovis* (Linnaeus)

Genus **FELICOLA** Ewing  
    *subrostrata* (Nitzsch)

Family PHILOPTERIDAE

Genus **ANOTOECUS** Cummings  
    *dentatus* (Scopoli)

\* Genus **DOCOPHOROIDES** Giglioli  
    *brevis* (Dufour)

Genus **SAEMUNDSSONIA** Timmerman  
    *conicus* (Denny)  
    *snyderi* (Kellogg and Paine)

- Genus **PHILOPTERUS** Nitzsch  
    *macgregori* (Kellogg and Chapman)  
    *subflavescens* (Geoffroy)
- Genus **RALLICOLA** Johnston and Harrison  
    *advena* (Kellogg)
- Genus **QUADRACEPS** Clay and Meinertzhagen  
    *birostris* (Giebel)  
    *oraria* (Kellogg)  
    *separata* (Kellogg and Kuwana)
- Genus **BRÜELIA** Kéler  
    *stenozone* (Kellogg and Chapman)  
    *vulgata* (Kellogg)
- Genus **PECTINOPYGUS** Mjoeberg  
    Subgenus *Epifregata* Harrison  
        *gracilicornis* (Piaget)  
    Subgenus *Pectinopygus* Mjoeberg  
        *sulae* (Rudow)
- Genus **HARRISONIELLA** Bedford  
    *ferox* (Giebel)
- Genus **PERINEUS** Harrison  
    *concinus* (Kellogg and Chapman)  
    *giganticulum* (Kellogg)
- Genus **COLUMBICOLA** Ewing  
    *columbae* (Linnaeus)
- Genus **LIPEURUS** Nitzsch  
    *caponis* (Linnaeus)
- Genus **CUCLOTOSTASTER** Carriker  
    *heterographus* (Nitzsch)
- Genus **OXYLIPEURUS** Mjoeberg  
    *polytrapezius* (Burmeister)
- Genus **LAGOPOECUS** Waterston  
    *docophoroides* (Piaget)
- Genus **GONIOCOTES** Burmeister  
    *chinensis* Kellogg and Chapman  
    *hologaster* Nitzsch
- Genus **GONIOIDES** Nitzsch  
    *dissimilis* Denny  
    *gigas* (Taschenberg)

**lativentris** Uchida  
**mammillatus** Rudow

Genus **CHELOPISTES** Kéler  
**meleagridis** (Linnaeus)

Species Incertae Sedis

**Degeeriella** (?) **diaprepes** (Kellogg and Chapman)  
**Degeeriella** (?) **minhaensis** (Kellogg and Chapman)

## Order ANOPLURA

Family HAEMATOPINIDAE

Subfamily HAEMATOPININAE

Genus **HAEMATOPINUS** Leach  
**asini** (Linnaeus)  
**eurysternus** (Nitzsch)  
**suis** (Linnaeus)

Subfamily HOPLOPLEURINAE

Genus **POLYPLAX** Enderlein  
**spinulosa** (Burmeister)

Genus **HOPLOPLEURA** Enderlein  
**oenomydis** Ferris

Subfamily LINOGNATHINAE

Genus **LINOGNATHUS** Enderlein  
**africanus** Kellogg and Paine  
**setosus** (Olfers)

Family PEDICULIDAE

Subfamily PEDICULINAE

Genus **PEDICULUS** Linnaeus  
**humanus humanus** Linnaeus  
**humanus capitis** Degeer

Subfamily PHTHIRINAE

Genus **PHTHIRUS** Leach  
**pubis** (Linnaeus)

Order **ODONATA**Suborder **ANISOPTERA**Superfamily **AESHNOIDEA**Family **AESHNIDAE**Subfamily **AESHNINAE**Tribe **AESHNINI**

Genus **ANAX** Leach  
    **junius** (Drury)  
    **strenuus** Hagen

Superfamily **LIBELLULOIDEA**Family **LIBELLULIDAE**Subfamily **LIBELLULINAE**

Genus **NESOGONIA** Kirby  
    **blackburni** (McLachlan)

Genus **PANTALA** Hagen  
    **flavescens** (Fabricius)

Genus **TRAMEA** Hagen  
    **lacerata** Hagen

Suborder **ZYGOPTERA**Superfamily **COENAGRIOIDEA**Family **COENAGRIIDAE**Subfamily **COENAGRIINAE**

Genus **MEGALAGRION** McLachlan  
    **adytum** (Perkins)  
    **amaurodytum amaurodytum** (Perkins)  
    **amaurodytum fallax** (Perkins)  
    **amaurodytum peles** (Perkins)  
    **amaurodytum waianaeaeum** (Perkins)  
    **blackburni** McLachlan

*calliphya calliphya* (McLachlan)  
*calliphya microdemas* (Perkins)  
*eudytum* (Perkins)  
*hawaiiense* (McLachlan)  
*heterogamias* (Perkins)  
*jugorum* (Perkins)  
*kauaiense* (Perkins)  
*koelense* (Blackburn)  
*leptodemas* (Perkins)  
*molokaiense* (Perkins)  
*nesiotes* (Perkins)  
*nigrohamatum nigrohamatum* (Blackburn)  
*nigrohamatum nigrolineatum* (Perkins)  
*oahuense* (Blackburn)  
*oceanicum* McLachlan  
*oresitrophum* (Perkins)  
*orobates* (Perkins)  
*pacificum* (McLachlan)  
*vagabundum* (Perkins)  
*williamsoni* (Perkins)  
*xanthomelas* (Selys-Longchamps)

Genus **ISCHNURA** Charpentier  
*posita* (Hagen)

Genus **ENALLAGMA** Charpentier  
*civile* (Hagen)

## Order **THYSANOPTERA**

### Suborder **TERREBRANTIA**

### Superfamily **AEOLOTHRIPOIDEA**

#### Family **AEOLOTHRIPIDAE**

#### Subfamily **AEOLOTHRIPINAE**

Genus **AEOLOTHRIPS** Haliday  
*fasciatus* (Linnaeus)

### Superfamily **THRIPOIDEA**

#### Family **THRIPIDAE**

#### Subfamily **HELIOTHRIPINAE**



Genus **HERCINOTHRIPS** Bagnall  
    *femoralis* (Reuter)

Genus **HERCOTHRIPS** Hood  
    *fasciatus* (Pergande)

Genus **HELIOTHRIPS** Haliday  
    *haemorrhoidalis* (Bouché)

Subfamily SERICOTHRIPINAE

Genus **DENDROTHRIPOIDES** Bagnall  
    *ipomeae* Bagnall

Genus **SCIRTOTHRIPS** Shull  
    *antennatus* Moulton

Genus **ANAPHOTHRIPS** Uzel  
    Subgenus *Chaetanaphothrips* Priesner  
        *orchidii* (Moulton)  
    Subgenus *Anaphothrips* Uzel  
        *obscurus* (Müller)  
        *secticornis* (Trybom)  
        *swezeyi* Moulton

Subfamily CHIROTTHRIPINAE

Genus **CHIROTTHRIPS** (Haliday)  
    *fulvus* Moulton  
    *mexicanus* Crawford  
    *spiniceps* Hood

Genus **APTINOTHRIPS** Haliday  
    *rufa* (Gmelin)

Genus **LIMOTHRIPS** (Haliday)  
    *cerealium* (Haliday)

Subfamily THRIPINAE

Genus **MEROTHRIPS** Hood  
    *hawaiiensis* Moulton  
    *morgani* Hood

Genus **SELENOTHRIPS** (Karny)  
    *rubrocinctus* (Giard)

Genus **SCOLOTHRIPS** Hinds  
    *sexmaculatus* (Pergande)

- Genus **FRANKLINIELLA** Karny  
    *fusca* (Hinds)  
    *sulphurea* Schmutz  
    *williamsi* Hood
- Genus **ORGANOTHRIPS** Hood  
    *bianchii* Hood
- Genus **LEUCOTHRIPS** Reuter  
    *piercei* (Morgan)
- Genus **DOCIDOTHRIPS** Priesner  
    *trespinus* (Moulton)
- Genus **BREGMATOTHRIPS** Hood  
    *venustus* Hood
- Genus **TAENIOTHRIPS** Amyot and Serville  
    *alliorum* Priesner  
    *cyperaceae* Bianchi  
    *frici* (Uzel)  
    *gracilis* Moulton  
    *hawaiiensis* (Morgan)  
    *simplex* (Morison)  
    *xanthius* (Williams)
- Genus **PLESIOTHRIPS** Hood  
    *panicus* (Moulton)
- Genus **THRIPS** Linnaeus  
    Subgenus **Microcephalothrips** (Bagnall)  
        *abdominalis* (Crawford)  
    Subgenus **Thrips** (Linnaeus)  
        *nigropilosus* Uzel  
        *saccharoni* Moulton  
        *tabaci* Lindeman  
        *trehernei* Priesner  
    Subgenus **Isoneurothrips** (Bagnall)  
        *antennatus* (Moulton)  
        *australis* Bagnall  
        *carteri* (Moulton)  
        *dubautiae* (Moulton)  
        *fasciatus* (Moulton)  
        *fullawayi* (Moulton)  
        *multispinus* (Bagnall)  
        *williamsi* (Moulton)

## Suborder TUBULIFERA

## Superfamily PHLAEOTHRIPOIDEA

## Family PHLAEOTHRIPIDAE

Genus **PHLAEOTHRIPS** Haliday*claratibia* Moulton*mauiensis* MoultonGenus **LIOTHRIPS** Uzel*floridensis* (Watson)Genus **POLYPOROTHRIPS** Watson*biformis* (Moulton)Genus **MACROPHTHALMOTHRIPS** Karny*hawaiiensis* MoultonGenus **NESOTHRIPS** Kirkaldy*oahuensis* KirkaldyGenus **DERMOTHRIPS** Bagnall*hawaiiensis* BagnallGenus **HOPLOTHRIPS** Amyot and Serville*angusticeps* (Bagnall)*barbatus* (Bagnall)*bicolor* (Bagnall)*coprosmae* Moulton*dubius* (Bagnall)*flavipes* (Bagnall)*flavitibia* Moulton*hawaiiensis* Moulton*intermedius* (Bagnall)*lanaiensis* (Bagnall)*laticornis* (Bagnall)*mauiensis* Moulton*nigricans* (Bagnall)*ovatus* (Bagnall)*paumalui* Moulton*perkinsi* (Bagnall)*swezeyi* MoultonGenus **AGNOSTOCHTHONA** Kirkaldy*alienigera* KirkaldyGenus **ALEURODOTHrips** Franklin*fasciapennis* (Franklin)

- Genus **KARNYOTHRIPS** Watson  
    *doliicornis* Bianchi  
    *flavipes* (Jones)  
    *melaleuca* (Bagnall)
- Genus **PODOTHRIPS** Hood  
    Subgenus **Kentronothrips** (Moulton)  
        *lucasseni* (Krüger)
- Genus **HAPLOTHRIPS** Amyot and Serville  
    Subgenus **Haplothrips** Amyot and Serville  
        *davisi* Bianchi  
        *fusca* Moulton  
        *gowdeyi* (Franklin)  
        *rosai* Bianchi  
    Subgenus **Hindsiana** Karny  
        *sakimurai* Moulton  
        *williamsi* Moulton
- Genus **RHAEBOTHRIPS** Karny  
    *major* Bagnall
- Genus **DICERATOTHRIPS** Bagnall  
    *brevicornis* Bagnall
- Genus **DICHAETOTHRIPS** Hood  
    *claripennis* Moulton  
    *setidens* (Moulton)

Superfamily UROTHRIPOIDEA

Family UROTHRIPIDAE

- Genus **CONOCEPHALOTHRIPS** Bianchi  
    *tricolor* Bianchi
- Genus **STEPHANOTHRIPS** Trybom  
    *occidentalis* Hood and Williams

## INTRODUCTION

### THE PHYLA OF ANIMALS, THE CLASSES OF TERRESTRIAL ARTHROPODS AND THE ORDERS OF INSECTS IN HAWAII

The Animal Kingdom is divided into a series of phyla. Perhaps all of the phyla are represented in Hawaii, but a few of the more obscure groups have not been recorded in literature as occurring here.

Zoologists vary in their concepts of phyla; the following list is representative of classifications proposed by various authorities.

Protozoa: unicellular animals.

Porifera: sponges.

Coelenterata: corals, sea anemones, hydroids, jellyfish.

Mesozoa: mesozoans.

Ctenophora: comb jellies, sea walnuts.

Platyhelminthes: flatworms, flukes, tapeworms.

Nemertinea: ribbon worms.

Nemathelminthes: roundworms, hookworms.

Gordiaceae: horse-hair worms.

Acanthocephala: spiny-headed worms.

Kinorhyncha: echinoderans.

Trochelminthes: wheel animalcules.

Chaetognatha: arrow worms.

Bryozoa: moss animals.

Brachiopoda: lamp shells.

Phoronidea: phoronideans.

Echinodermata: starfish, sea urchins, sea cucumbers.

Mollusca: snails, squids, octopi.

Annelida: segmented worms, earthworms, leeches, tube worms.

Arthropoda: crustaceans, arachnids, centipedes, millepedes, mites, spiders, insects, etc.

Chordata: tongue worms, tunicates, ascidians, vertebrates, etc.

The phyla in turn are divided into classes. The insects belong to the phylum Arthropoda, and it is in these animals with jointed legs that our interest lies. The arthropods are distinguished from other animals because they have segmented bodies whose exoskeletons contain chitin; some of the segments carry jointed appendages at some stage of the life history. Some arthropods frequently are referred to as insects, although they belong to distinct classes. The following key elucidates the characters whereby the insects can be differentiated from other arthropods in Hawaii:

## KEY TO THE CLASSES OF ADULT TERRESTRIAL ARTHROPODS OF HAWAII

1. With more than four pairs of legs..... 2  
 With two, three or four pairs of legs..... 6
- 2(1). With two pairs of antennae..... **Crustacea**.  
 With only one pair of antennae..... 3
- 3(2). Antennae branched distad; minute soil- or humus-inhabiting animals with six to ten somites, nine pairs of legs and no respiratory organ system..... **Paupoda**.  
 Antennae not branched..... 4
- 4(3). Most somites apparently bearing two pairs of legs.. **Diplopoda**.  
 Body segments each bearing not more than one pair of legs.. 5
- 5(4). Tarsal claws single; fifteen or more pairs of legs; spiracles numerous and on the pleura or dorsa of the post-cephalic somites; with a pair of well-developed six-segmented poison fangs in addition to mandibles and maxillae...  
 ..... **Chilopoda**.  
 Tarsal claws paired; twelve pairs of legs; a single pair of spiracles, and these opening on the head; without poison fangs..... **Symphyla**.
- 6(1). With four pairs of legs..... 7  
 With two or three pairs of legs..... 8
- 7(6). Microscopic, subterranean or aquatic arthropods lacking a respiratory organ system and without an external genital opening; legs each with several claws or specialized vesicles ..... **Tardigrada**.  
 Respiratory organ system developed, consisting of book lungs or spiracles and tracheae or both; reproductive system opening near base of abdomen; cephalothorax usually bearing two pairs of appendages, one of which is usually chelate, in addition to legs..... part of **Arachnida**.
- 8(6). With two pairs of legs; minute animals with the after-body covered with numerous microscopic, transverse folds or striae; abdomen fused to cephalothorax.....  
 ..... part of **Acarina** of **Arachnida**.  
 With three pairs of legs; head, thorax and abdomen distinct ..... **Insecta**.

The phylum Arthropoda contains more species of animals than all the other phyla combined. There may be two million or more different kinds. The species are distributed from the floor of the deep oceans to high mountains, from torrid deserts to polar seas.

All the classes of terrestrial arthropods except the Onychophora and Pentastomida are represented in Hawaii. We are sure that the classes Crustacea, Diplopoda, Arachnida and Insecta contain endemic species, but the status of the members of some of the other classes is uncertain; they may all be immigrants. The insects are most easily separated from their allies because they have six legs.

Some insects are primarily wingless; insofar as we know, their ancestors never had wings. These forms are grouped together in the subclass Apterygota. How-

ever, there are certain members of the subclass Pterygota which have lost their wings secondarily, and for that reason it is essential to insert some of the orders which contain such wingless species in the Apterygota section of the following key to the orders of adult insects found in Hawaii. It is for this reason, therefore, that such orders as Hymenoptera will be found in two places in the key.

Some of the characters used in the key apply only to the Hawaiian members of a group and do not include various aberrant forms found elsewhere. The key is perhaps weak in a number of places, but it can only be improved by use and subsequent correction.

#### KEY TO THE ORDERS OF ADULT INSECTS OF HAWAII

1. Wings absent (including wingless forms of normally winged groups as well as typical Apterygota) ..... 2
- Wings present, sometimes rudimentary, but never absent .... 21
- 2(1). With one or more pairs of ventral abdominal appendages (styli or uropods) and often one or two terminal abdominal appendages in addition to cerci and external genital appendages, although cerci may be absent (Apterygota) ..... 3
- With at most terminal cerci and external genital appendages, never with additional ventral abdominal appendages (wingless Pterygota) ..... 6
- 3(2). Antennae absent ..... **Protura.**
- Antennae present ..... 4
- 4(3). Abdomen not more than six-segmented, often, but not always, with a ventral springing organ on fourth ventrite; compound eyes absent, the eyes consisting of groups of separated simple eyes arranged in an "eye patch" ..... **Collembola.**
- Abdomen with more than six segments, terminating either in a pair of unsegmented forceps or, more usually, with a pair of many-segmented cerci and with or without a third, median, cerciform appendage ..... 5
- 5(4). Eyes present and body densely squamose in our species; a many-segmented, median, cercus-like caudal appendage in addition to the long, filamentous, many-segmented cerci; trophi external, not retracted into the head ..... **Thysanura.**
- Eyes absent; body without scales; cerci either many-segmented or forceps-like but without a median caudal filament; trophi hidden within head ..... **Diplura.**
- 6(2). Cerci present ..... 7
- Cerci absent ..... 13
- 7(6). Body greatly and conspicuously compressed laterally, much higher than broad (placed here because of difficulty of identifying cerci) ..... **Siphonaptera.**
- Not as above ..... 8

- 8(7). Tarsi two-segmented; cerci one-segmented, not forceps-like ..... **Zoraptera**.  
Tarsi with three, four or five segments; cerci either forceps-like or two- to many-segmented..... 9
- 9(8). Cerci single-segmented and forceps-like.....  
.....wingless **Dermaptera**.  
Cerci two- or more-segmented, not forceps-like.....10
- 10(9). First segment of fore tarsi greatly inflated.....  
.....wingless **Embioptera**.  
First tarsal segment not abnormally enlarged.....11
- 11(10). Tarsi four-segmented; social species living in wood or wood products.....wingless **Isoptera**.  
Tarsi three- or five-segmented.....12
- 12(11). Wood-boring social insects; bodies soft, white or pale-colored; first tarsal segment short.....wingless **Isoptera**.  
Not wood-boring social species; bodies well-pigmented; first tarsal segment elongate.....some wingless **Orthoptera**.
- 13(6). Body greatly and conspicuously compressed laterally, much higher than broad; small, active, jumping ectoparasites .....**Siphonaptera**.  
Body not laterally compressed.....14
- 14(13). Body larviform, sac-like, legless, head and thorax fused, antennae and eyes absent; parasites of Hymenoptera and leafhoppers.....female **Strepsiptera**.  
Not such degenerate insects.....15
- 15(14). Tarsi one- or two-segmented, terminating in a bladder-like organ .....**Thysanoptera**.  
Tarsi one- to five-segmented, but never terminating in a bladder-like organ, claws well-developed.....16
- 16(15). Mouth parts fitted with mandibles for chewing.....17  
Mouth parts modified into sucking organs, often styliform and adapted for piercing.....19
- 17(16). Abdomen constricted at base and joined to thorax by a narrow petiole.....wingless **Hymenoptera**.  
Abdomen not greatly constricted at base, broadly joined to thorax .....18
- 18(17). Antennae with three to five segments; ectoparasites.....  
.....**Mallophaga**.  
Antennae with nine or more segments; not parasitic.....  
.....wingless **Corrodentia**.
- 19(16). Tarsi five-segmented .....wingless **Diptera**.  
Tarsi with three or fewer segments.....20
- 20(19). Mouth parts issuing from anterior end of head, retracted when not in use; small, depressed ectoparasites... **Anoplura**.  
Mouth parts not capable of being entirely withdrawn, usually arising from ventral side of head, usually obvious, often very long.....wingless **Hemiptera**.



- 21(1). With only two well-developed wings.....22  
 With four wings (fore pair often modified, horny or leathery and of different consistency than hind pair).....25
- 22(21). Fore wings represented by a pair of clavate processes, hind wings well-developed .....**Strepsiptera.**  
 Fore wings well-developed, hind wings represented by a pair of halteres, greatly reduced or absent.....23
- 23(22). Abdomen with greatly elongated caudal filaments; with but a single, forked vein in wings; minute insects (male coccids) .....**Hemiptera.**  
 Abdomen without long caudal filaments; wings usually with complex venation .....24
- 24(23). Mouth parts fitted with well-developed mandibles for biting and chewing; palpi long and conspicuous, maxillary palpi five-segmented, labial palpi three-segmented (some aberrant Hemerobiidae) .....**Neuroptera.**  
 Mouth parts fitted for lapping, sucking or piercing; mandibles, if present, incorporated with proboscis and not obvious as mandibles; maxillary palpi, if distinguishable, not more than four-segmented, labial palpi absent.. **Diptera.**
- 25(21). Abdomen terminating in two or three long, filamentous structures (cerci and median caudal filament); wings held vertically when at rest, with many cross-veins and intercalary veins, hind pair much smaller than fore pair; mouth parts vestigial; nymphs aquatic.....**Ephemeroptera.**  
 Not such insects.....26
- 26(25). Mouth parts fitted for piercing and sucking or for sucking; conical, stylet-like, siphon-like or vestigial, not mandibulate .....27  
 Mouth parts with mandibles usually fitted for biting and chewing (developed but not used as biting or chewing organs in some Hymenoptera, however).....30
- 27(26). Tarsi terminating in a bladder-like organ; wings linear and usually with long fringes of hairs, with only one or two longitudinal veins or none.....**Thysanoptera.**  
 Tarsi without such bladder-like organs; wings usually with more complex venation.....28
- 28(27). Not clothed with scales; fore wings usually, at least proximally, of a denser consistency than hind pair; proboscis not coiled .....**Hemiptera.**  
 Wings and body densely clothed with either hairs or scales; fore and hind wings of similar texture, entirely membranous; proboscis either coiled or wanting.....29
- 29(28). Wings roughly hairy; mouth parts, except palpi, vestigial .....**Trichoptera.**  
 Wings densely covered with scales; mouth parts usually developed into a conspicuous, coiled proboscis.. **Lepidoptera.**
- 30(26). Fore wings leathery or corneous, not membranous, but of denser texture than membranous hind wings.....31  
 Fore and hind wings membranous and of similar texture...33

- 31(30). Fore wings parchment-like or leathery, usually with a distinct complex of veins, but if with obscured venation, as in some Blattidae, then hind wings, as in the rest of the order, folded lengthwise like fans and never crosswise ..... **Orthoptera.**  
 Fore wings uniformly horny or leathery and normally without any venation; hind wings folded both crosswise (except in plagithmysine longicorns) and lengthwise ..... 32
- 32(31). Cerci present and modified into conspicuous sclerotized forceps; hind wings semicircular, with peculiarly radiating veins and folds. .... **Dermaptera.**  
 Cerci absent; hind wings without such venation. .... **Coleoptera.**
- 33(30). First fore-tarsal segment greatly inflated; cerci two-segmented; both pairs of wings similar. .... **Embiopoda.**  
 First fore-tarsal segment not abnormally inflated. .... 34
- 34(33). Tarsi two- or three-segmented. .... 35  
 Tarsi four- or five-segmented. .... 37
- 35(34). Antennae very short, inconspicuous, setaceous, not more than seven-segmented; wings with a complex reticulate arrangement of cross-veins, held either horizontal or vertical when at rest. .... **Odonata.**  
 Antennae with nine to many segments, long and conspicuous; wings with few veins and cross-veins. .... 36
- 36(35). Wings folded flat over back when at rest and with a subbasal "fracture suture" at which point wings may be shed; maxillary palpi five-segmented, labial palpi three-segmented ..... **Isoptera.**  
 Wings normally held roof-like over body and without a "fracture suture"; maxillary palpi four-segmented, labial palpi one- or two-segmented. .... **Corrodentia.**
- 37(34). Abdomen with a conspicuous basal constriction and joined to the "thorax" by a narrow petiole; hind wings capable of being hooked to fore wings by a row of sclerotized hooks ..... **Hymenoptera.**  
 Abdomen broadly joined to thorax and without a distinct basal constriction; hind wings not hooked to fore wings. .... 38
- 38(37). Tarsi four-segmented; wings folded flat over back when at rest and provided with a subbasal "fracture suture," the part of the wing beyond the suture deciduous and the insects thus frequently found with only stumps of wings present ..... **Isoptera.**  
 Tarsi five-segmented; wings held roof-like over body when at rest and without a "fracture suture" .... **Neuroptera.**

## Subclass **APTERYGOTA** (Brauer) Lang, 1889

(*a*, not; *pterygos*, wing)

*Apterygogenea* Brauer, 1885.

The orders of this subclass are the Thysanura, Diplura, Protura and Collembola. They can be distinguished from the adults of the orders of the Pterygota because they have one to several pairs of abdominal appendages in addition to external genitalia and cerci. They are primitively wingless creatures with little or no metamorphosis and most are cryptic in habit. The group as a whole is poorly known, but studies of some of its species have aided greatly in the interpretation of the ancestry, relationships and development of insects. With the debatable exception of the Thysanura and Diplura, the four orders are not closely allied to one another. In fact, the orders Thysanura, Collembola and Protura display such diversity in structural characters that little remains by which to associate the groups.

Members of all of the known orders of the Apterygota have been found in Hawaii, but not all of them are represented by endemic forms.

## Order **THYSANURA** Latreille, 1796

(*thysanos*, tassel or fringe; *oura*, tail)

Lepismatids, Silverfish, Fishmoths, Machilids, Bristletails, Rockjumpers

This order includes primitively apterous insects of an ancient type with exposed, chewing mouth parts; filiform or moniliform, many-segmented antennae and cerci as well as a filiform, many-segmented, cerciform, median, caudal appendage; compound eyes present (except in Nicoletiinae of Lepismatidae); body densely squamose in the Hawaiian species, the scales imbricated; abdomen 11-segmented, at least some of the ventrites with lateral styli (really on the lateral plates or coxites) and usually with protrusible vesicles; tarsi three- or four-segmented, claws paired; metamorphosis incomplete, only slight changes other than size between the first instar and adult.

The group is composed of slippery, fast-running or jumping, elusive, mostly nocturnal insects of cryptic habits found in trash, litter on the forest floor, under bark, as commensals in ants' nests, under stones or in buildings, where some species (see Lepismatidae) constitute a nuisance of considerable economic importance. The species have the strange ability to regenerate the antennae and caudal appendages if these organs are broken.

Little is known concerning the species found in Hawaii. The group has been largely neglected by workers in Hawaii and considerable confusion exists in local literature pertaining to them. Only one systematic study has been made of the

Hawaiian species, and that is Silvestri's report in *Fauna Hawaiiensis* (1904). Biological studies of a "*Lepisma*" were made by Morita (1926), but the species was apparently misidentified (see notes under *Ctenolepisma*).

Too little is known concerning the Hawaiian species to enable any definite conclusions regarding the endemicity of the insects of this order to be reached at this time. In my opinion, the only species that might be endemic appear to be the two machilids. It seems improbable that any of the Lepismatidae are endemic, in spite of the fact that one has been described as *Lepisma hawaiiensis* by Silvestri. A detailed, comparative study must be made of all the Hawaiian species of the order before any concrete information can be presented. The habits of some species fit them for easy dispersal by commerce, and some have become widespread about the world.

The only record of parasites of Thysanura that has come to my attention is that of a strepsipteron on a *Lepisma* in France (see the section on Lepismatidae for details).

Fossil thysanurans are known from Oligocene and Miocene deposits.

TABULAR ANALYSIS OF THE HAWAIIAN THYSANURA

FAMILY	GENERA	ENDEMIC GENERA	NON-ENDEMIC GENERA	SPECIES	ENDEMIC SPECIES	ADVENTIVE SPECIES
Machilidae	1	0	1	2	2	0
Lepismatidae	5	0	5	6	0	6
Totals	6	0	6	8	2	6

Percentage of endemism in native group: genera, 0 percent; species, 100 percent.

Percentage of present-day fauna native: 25 percent.

Percentage of present-day fauna adventive: 75 percent.

Average number of species per genus in native group: 2.0.

Average number of species per genus in adventive group: 1.2.

The figures in this table, and in the similar tables which follow in the remaining chapters, may be explained as follows:

1. "Percentage of endemism in native group: genera" means the percentage obtained by dividing the number of endemic genera by the total number of genera containing native (endemic and indigenous) species. The result is the percent of the total number of genera which contain native species which are endemic genera.

2. "Percentage of endemism in native group: species" means the percentage obtained by dividing the number of endemic species by the total number of endemic plus indigenous species.

3. "Percentage of present-day fauna native" is obtained by dividing the total number of endemic plus indigenous species by the total number of species recorded from the islands (endemic + indigenous + adventive).

4. "Percentage of present-day fauna adventive" is, similarly, the total number of species divided into the total of adventive species.

5. The average number of species per genus is obtained simply by dividing the total number of species in the native or adventive group by the total number of genera containing those species.

For purposes of simplification, I have combined species and lesser categories and have given them all equivalent rank. There are only about 50 subspecific names to consider, and the status of some of them is in doubt.

The two families of the order, both of which are represented in the Hawaiian fauna, may be separated as follows:

#### KEY TO THE FAMILIES OF THYSANURA

1. Compound eyes large, dorsally approximate or contiguous, body subcylindrical or somewhat laterally compressed rather than depressed; face narrower than base of an antenna between antennae; thorax gibbose; jumping insects (Machilids, Rockjumpers, Bristletails) ..... **Machilidae.**
2. Compound eyes small and widely separated, situated near sides of head or absent; body dorso-ventrally depressed; face broad between antennae (excepting in Nicoletiinae); thorax not gibbose; swift-running, not jumping insects; (Lepismids, Silverfish, Fishmoths) ..... **Lepismatidae.**

#### Family MACHILIDAE Grassi, 1888

##### Bristletails, Rockjumpers, Machilids

In Hawaii, this family includes two silvicolous species which appear to be endemic.

Compound eyes large, conspicuous, consisting of a large number of facets, occupying much of the front of the head and contiguous or approximate above; below each eye is a conspicuous, elongate organ, the two of which are called the paired ocelli; medially, toward the clypeus is another organ, of unknown function, called the single ocellus; face, between the antennae, narrower than the base of an antenna; maxillary palpi long, seven-segmented and held in such an attitude as to resemble legs; labial palpi three-segmented; antennae long, filamentous, composed of a large number of secondarily subdivided segments; mandibles composed of a single sclerite with distantly separated toothed incisor and molar areas and with a single basal articulation to the head; mid and hind coxae with styli in the Hawaiian species; tarsi three-segmented; abdominal coxites bearing styli on segments two to nine and exsertile vesicles on segments two to seven inclusive in the Hawaiian species.

The Hawaiian species may be found among trash, limbs and other material on the forest floor, under bark, in rotting stumps and logs, in dead tree-fern fronds and in bunch grass. They are walking insects which jump agilely. The conspicuously hunchbacked thorax, peculiar ocelli and the long styli, which resemble walking appendages, on abdominal segments two to nine are features which easily serve to distinguish the machilids from the silverfish.

Machilids are represented as fossils in Oligocene Baltic amber. Tillyard (1926) considered them to be probably the most primitive of insects.

#### Subfamily MEINERTELLINAE

This subfamily includes species which have the median ventrites of the abdomen mostly or entirely hidden and each coxite has one protrusible vesicle or none.

Genus **MACHILOIDES** Silvestri, 1905*Nesomachilus* Tillyard, 1924.

The Hawaiian members of this genus have exsertile vesicles on abdominal coxites two to seven, styli on segments two to nine, styli on the mid and hind coxae, and the paired ocelli are elongate, not triangular. The Hawaiian species were described in *Machilis*, but they cannot now be left in that genus. No information is available regarding the life histories or food habits of the Hawaiian species.

KEY TO THE HAWAIIAN SPECIES OF **MACHILOIDES**

1. Maxillary palpus of male with terminal segment elongate, awl-shaped, three terminal segments all slender and elongate, penultimate segment not much longer nor much broader than distal one; fore tibia of male enlarged, only slightly longer than broad.....**heteropus** (Silvestri).
2. Maxillary palpus of male with last three segments short and stout, penultimate segment distinctly longer and much broader than distal segment which is vaguely reniform, in any case not long and awl-shaped; fore tibia of male about twice as long as broad.....**perkinsi** (Silvestri).

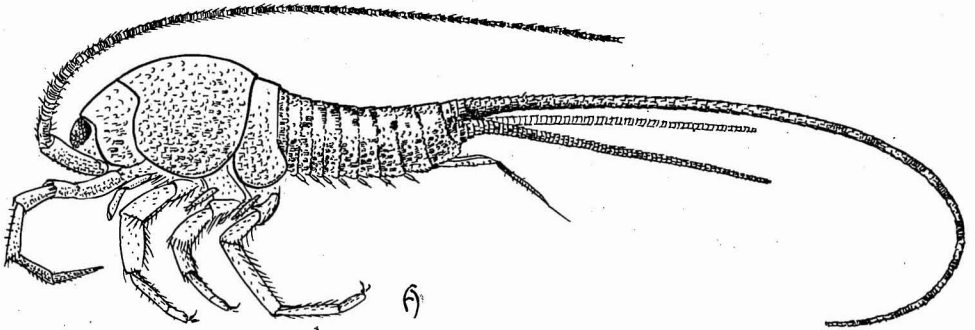


Figure 1—*Machiloides heteropus* (Silvestri). (Abernathy drawing.)

***Machiloides heteropus*** (Silvestri), new combination (fig. 1).

*Machilis heteropus* Silvestri, 1904:295, pl. 8, figs. 14–16, 18.

Endemic. Kauai, Oahu, Lanai, Maui, Hawaii (no specific type locality given by author).

Habit: under dead bark, in dead tree-fern fronds, in rotting wood.

***Machiloides perkinsi*** (Silvestri), new combination.

*Machilis perkinsi* Silvestri, 1904:294, pl. 8, figs. 8–13.

Endemic. Kauai (type locality: mountains behind Waimea, 4,000 feet).

## Family LEPISMATIDAE (Lubbock)

*Lepismidae* Lubbock, 1873.

## Lepismatids, Silverfish, Fishmoths

Compound eyes, if present, small, situated at the sides of the head and widely separated (absent in Nicoletiinae); ocelli absent; mandibles composed of a single sclerite with a well-sclerotized, dentate incisor area but without a distinct molar region, with two articulations with the head; maxillary palpi five- or six-segmented; labial palpi four-segmented; antennae moniliform or filamentous, very long in most species (moniliform and comparatively short only in some Nicoletiinae); coxae without styli; tarsi three- or four-segmented; some of the abdominal coxites with styli and with protrusible vesicles present or wanting.

Fossil lepismatids have been found in Miocene deposits at Florissant, Colorado, and in Oligocene Baltic amber.

The Hawaiian species are usually seen about buildings, but they are also to be found afield in trash, in bunch grass, under bark, under stones along the seashore and inland, and in the nests of some species of ants. The several species found in dwellings, factories and offices are of considerable economic importance because of the severe damage they cause to book bindings, labels, drawings, wall paper (they eat the glue between the paper and wall and cause the paper to loosen), cellophane, maps, pictures, starched clothing, pasted or glued materials, most any article made of certain kinds of paper (especially glazed and sized brands) or other materials that contain palatable starchy ingredients. They are also reported to damage linens, furs, woolens, sized silks, carpets, insect collections, farinaceous materials; rayons appear to be a favorite food of some species. Nothing is known of the food habits of our species afield. The ant-loving species are said to eat

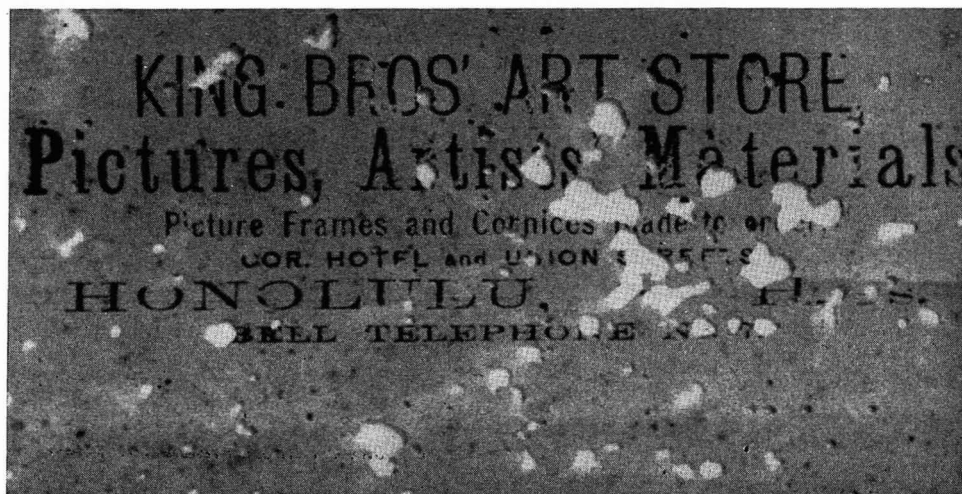


Figure 2—Part of the paper backing on a framed picture showing typical damage caused by the silverfish *Ctenolepisma urbana* Slabaugh.



regurgitated food from ants and even to excite the ants into releasing food by stroking them with their antennae. Some extra-Hawaiian species are found in termite nests (in Australia, for example).

Control: In heavily infested buildings or in rooms that can be closed tightly, cyanide fumigation is most effective and kills all stages, and if repeated at intervals of a few months, will keep damage at a minimum. Although one may kill off all individuals and their eggs in the building or room fumigated, reinfestation occurs from the gradual influx of individuals from the outside. A 5 percent solution of DDT sprayed over surfaces frequented by silverfish gives good control and is replacing the older methods, some of which are listed below.

The arsenic-flour-water pastes recommended for use in the continental United States and elsewhere have proved worthless in Hawaii. Cards painted with such mixtures have been exposed in my laboratories for several years without being touched by silverfish. An effective bait, however, is a sodium fluoride-flour mixture. I have used with success a dry mixture of three parts sodium fluoride powder to seven parts white flour, mixed well in a closed container (avoid breathing the poison) and placed in open pill boxes which are scattered around infested rooms, behind books in book cases, in drawers, in closets, under cabinets, on shelves and other places. Mallis (1944:842), who has carried on extensive silverfish poisoning tests, has found that a 5 percent sodium fluoride-95 percent flour mixture is fully as effective as higher concentrations of the poison. The bait should be replaced two or more times a year for effective control. I have found naphthalene flakes effective not only in keeping the pests away but in killing silverfish in such closed places as drawers, cupboards, closets and boxes. Paradichlorobenzene crystals can be used in the same way with excellent results. The latter substance lends itself well to home fumigation of closets and other closed places. It is more volatile than naphthalene and is a more effective fumigant. The use of cyanide fumigation one to three times a year in combination with poison baits normally will prevent serious damage. Pyrethrum powder or sodium fluosilicate dusted about infested places is recommended by some workers. Traps made from jars, bottles or glasses standing upright with tape or other rough material placed on the outside to give footing and baited with flour, glued paper or other articles known to be attacked by silverfish, are used by some people. The silverfish climb into the vessels but cannot get out because of the smooth interior glass walls of the containers. A poison to protect books from silverfish, cockroaches and Mexican book beetles is used by several libraries in Hawaii. Its formula is one ounce of white powdered corrosive sublimate and one ounce of carbolic acid crystals dissolved in one quart of ethyl alcohol. Some workers add four ounces of white shellac, which helps protect the bindings from wear. The solution is applied with a brush. It is very poisonous and is not to be used on leather.

Carpentier (1939) records the strepsipteron *Eoxenos laboulbenei* Peyerimhoff as a parasite of *Lepisma aurea* in France. The parasite also occurs in North America. This is a most unusual record of parasitism, and I am not acquainted with other parasites of silverfish.



Pemberton (1928:147) records a predaceous lepismatid which lives in the nests and galleries of termites in British North Borneo. He says that it resembles a small *Lepisma* and that it feeds upon the eggs and nymphs of termites. An attempt was made to introduce the silverfish into Hawaii, but the culture died out before it could be released.

Lepismatids appear to enjoy a lengthy life. Individuals have been kept alive in cultures for about four years.

The tapering, roughly fish-shaped body clothed with large overlapping scales which are silvery in some species makes many of the lepismatids slippery and difficult to pick up; hence the common name, "silverfish."

#### KEY TO THE SUBFAMILIES OF LEPISMATIDAE FOUND IN HAWAII

1. Eyes present ..... **Lepismatinae.**
2. Eyes absent ..... **Nicoletiinae.**

#### Subfamily LEPISMATINAE

The number of species found in Hawaii is not yet definitely known, but it is believed that several species additional to those listed are present in the Hawaiian Islands.

#### KEY TO THE GENERA OF LEPISMATINAE FOUND IN HAWAII

1. Caudal tergite long, V-shaped..... **Acrotelsella.**
2. Caudal tergite U-shaped, or truncate or emarginate, but never long and sharply pointed..... **Ctenolepisma.**

#### Genus **ACROTELSELLA** Silvestri, 1934:307

#### KEY TO THE SPECIES FOUND IN HAWAII

1. Dorsal scales predominantly black, but with a sharply contrasting, conspicuous band of white scales across posterior margin of pronotum; pronotum with a comb of setae between middle and each side of fore margin..... **collaris** (Fabricius).
2. Dorsal scaling brownish, without a white band on pronotum and without such combs of setae..... **hawaiiensis** (Silvestri).

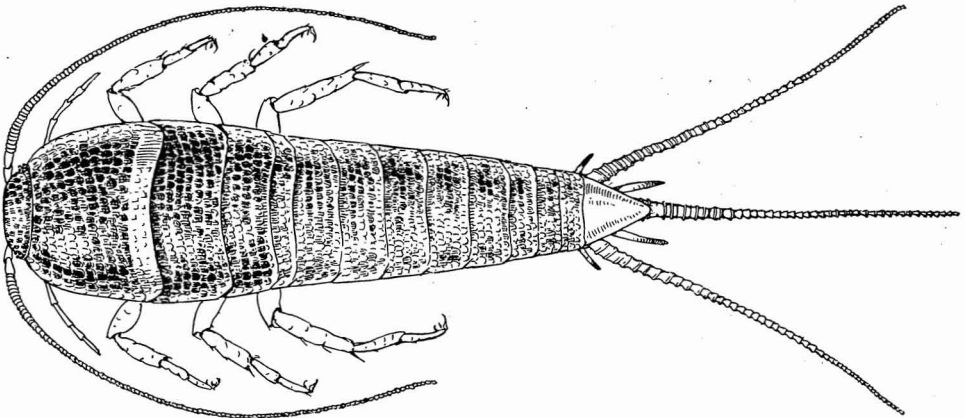


Figure 3—*Acrotelsella collaris* (Fabricius). (Abernathy drawing.)

**Acrotelsella collaris** (Fabricius) (fig. 3).*Lepisma collaris* Fabricius, 1793:64. Sharp, 1910:185, fig. 93.*Lepisma cincta* Oudemans, 1890:80.*Acrotelsa collaris* (Fabricius) Escherich, 1904:107, fig. 43 *a,b*; pl. 1, fig. 3.

Oahu.

Immigrant. Described from the West Indies. Evidently widespread in the tropics; Samoa, Fiji, Java. First recorded in Hawaii by Swezey in 1925.

Under bark and in buildings.

**Acrotelsella hawaiiensis** (Silvestri), new combination.*Lepisma hawaiiensis* Silvestri, 1904:296, pl. 8, figs. 19-27.

Kauai (type locality, 4,000 feet), Oahu, Nihoa, Necker.

Immigrant(?).

Under bark in forests; under stones near shore.

Genus **CTENOLEPISMA** Escherich, 1905**Ctenolepisma urbana** Slabaugh (figs. 2, 4, 5).*Ctenolepisma urbana* Slabaugh, 1940:95, pl. 3, figs. 1-3, 5-6, 8, 10-12.

Oahu (and other main islands?).

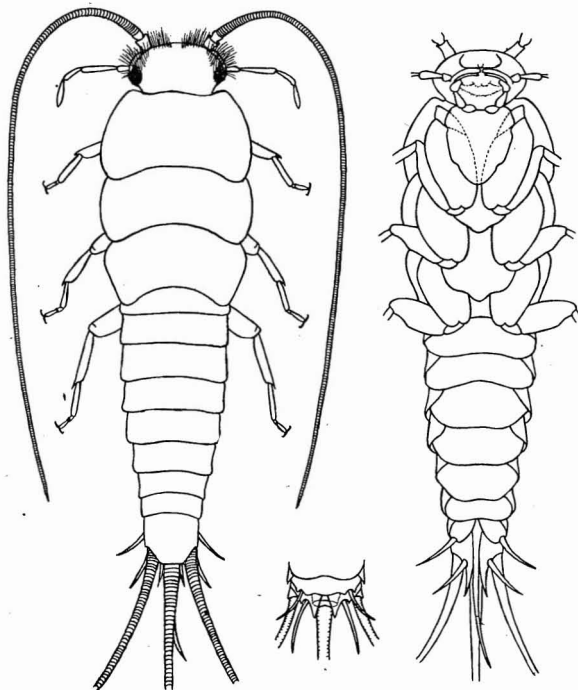


Figure 4—*Ctenolepisma urbana* Slabaugh: dorsal (left) and ventral (right) views of female to show details, vestiture removed, with an insert sketch of ventral view of apex of abdomen of male.

Immigrant. Described from Urbana, Illinois, but immigrant to North America. Long known as a common silverfish pest in buildings in Hawaii, but confused under the name *Lepisma saccharina* Linnaeus.

This is a serious pest in Hawaii, and it causes a large amount of damage. Morita's biological studies (1926) probably apply to it. For notes on control, see the preceding discussion, which was written particularly for this species. When damage is discovered, the insects causing it may often be found hiding near-by.

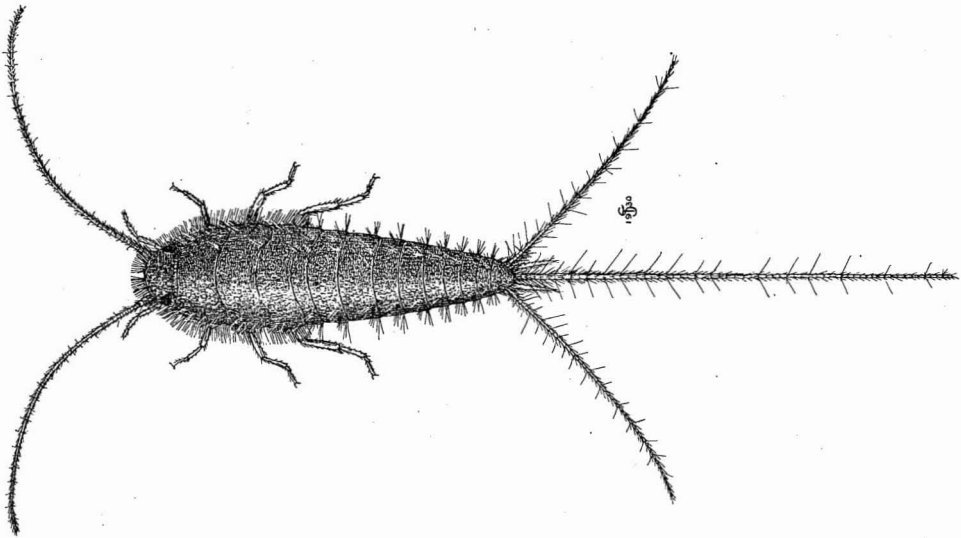


Figure 5—*Ctenolepisma urbana* Slabaugh. (From Twigg-Smith's original drawing for Williams, 1931.)

#### Subfamily NICOLETHINAE

#### Genus **NICOLETIA** Gervais, 1843

#### Subgenus **Anelpistina** Silvestri, 1905:111

#### **Nicoletia** (*Anelpistina*) **meinerti** Silvestri.

*Nicoletia* (*Anelpistina*) *meinerti* Silvestri, 1905:114, pl. 11, figs. 14–17:

#### Oahu.

Immigrant. Described from South America, known also from Europe and reported from the Marquesas Islands. First recorded from Hawaii by Silvestri (1912:218, fig. x) from specimens collected on Mount Tantalus in 1908.

Probably to be found in Hawaii, as in the Marquesas (see Silvestri, 1934:311), under rotting bark, in rotting banana stems and in decaying wood.

#### **Genus(?) species(?)** (fig. 6).

A small, yellow, immigrant species has been found in nests of *Pheidole megacephala* and *Tetramorium guineense* on Oahu, but it has not been determined.

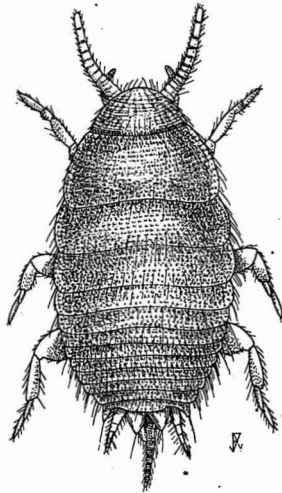


Figure 6—A small, golden-yellow, unidentified lepidopteran found in the nests of ants in Hawaii. (Drawing by F. X. Williams.)

#### Genus(?) species(?)

A small, dark, unidentified immigrant species with black scales with iridescent reflections, with a white band of scales along posterior margin of pro- and mesothorax, white patches along hind margin of metathorax, a median white patch and two lateral white patches on abdomen, has been found on desks at the Hawaiian Sugar Planters' Association Experiment Station and elsewhere in Honolulu since 1929.

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The bibliography for this order is placed at the end of the Collembola section (p. 69).

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### Order **DIPLURA** Börner, 1904

(*diploos*, double; *oura*, tail)

*Entotrophi* Grassi, 1888.

*Campodeoidea* Handlirsh, 1903.

*Aptera* of Essig, 1942.

#### Campodeids, Japygids

Body squamose or not in our species; mouth parts of the chewing type, concealed in head; without eyes or ocelli; antennae many-segmented, long, filamentous; thoracic segments distinct, unusual in having three or four pairs of thoracic spiracles, abdomen 11-segmented, some of the ventrites usually with styli and protrusible vesicles; cerci either forceps-like, segmented or filiform; without a median, cerciform, caudal appendage; tarsi single-segmented, claws paired; metamorphosis slight.

This is a group of pale, blind insects of obscure habits leading a subterranean existence. They may be collected from soil and humus by flotation in water, by sifting or by the use of a Berlese funnel. Occasionally they may be found beneath logs, rocks and other objects on the ground or in decaying wood. Nothing is known regarding the life histories of the Hawaiian species.

Our knowledge of the order is insufficient to enable us to say which members of the Hawaiian group are or are not native. It appears best to assume that all of our species are immigrants. Perkins thought that *Japyx sharpi* Silvestri might be endemic, and he noted that a campodeid (*Plusiocampa perkinsi*?) was found in soil imported around plants (1913:ccxx).

I do not know of any records of insect parasites of members of this order.

TABULAR ANALYSIS OF THE HAWAIIAN DIPLURA

FAMILY	GENERA	ENDEMIC GENERA	NON-ENDEMIC GENERA	SPECIES	ENDEMIC SPECIES	ADVENTIVE SPECIES
Campodeidae	2	0	2	2	0	2
Japygidae	2	0	2	2	0	2
Totals	4	0	4	4	0	4

Percentage of present-day fauna native: 0 percent.

Percentage of present-day fauna adventive: 100 percent.

Average number of species per genus: 1.

#### KEY TO THE FAMILIES OF DIPLURA FOUND IN HAWAII

1. Caudal appendages (cerci) many-segmented, long, filiform, antennae-like; without styli on first abdominal ventrite ..... **Campodeidae.**
2. Caudal appendages (cerci) single-segmented forceps; with styli on first abdominal segment. .... **Japygidae.**

#### Family CAMPODEIDAE Westwood, 1873

Antennae with 16 to about 40 segments in our species; mandibles composed of a single sclerite with a dentate incisor area and with a single articulation with the head; palpi reduced or vestigial; abdominal ventrites two to seven with styli and protrusible vesicles; cerci eight- or nine-segmented in our species.

Campodeids are easily distinguished, pale, soil-inhabiting insects, with antennae-like cerci and mostly less than 5 mm. long.

#### KEY TO THE GENERA FOUND IN HAWAII

1. Antennae with less than 20 segments; body not scaled. .... **Plusiocampa** Silvestri.
2. Antennae with more than 30 segments; body squamose. .... **Lepidocampa** Oudemans.

#### Genus PLUSIOCAMPA Silvestri, 1912

#### Subgenus Microcampa Silvestri, 1934:519

Femora without dorsal macrochaetae; abdominal tergites one to seven without macrochaetae.

**Plusiocampa (Microcampa) perkinsi** Silvestri.

*Plusiocampa (Microcampa) perkinsi* Silvestri, 1934:519, figs. 1, 2. Type of subgenus.

Oahu (type locality: Honolulu).

Immigrant. Origin unknown.

Abundant in sugarcane soil.

Genus **LEPIDOCAMPA** Oudemans, 1890**Lepidocampa giffardii** Silvestri (fig. 7).

*Lepidocampa giffardii* Silvestri, 1931:282, figs. 4, 5.

Oahu, Hawaii (type locality: Hilo).

Immigrant. Origin undetermined.

Found in soil and in rotten logs.

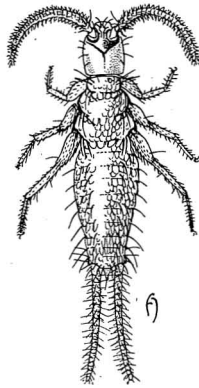


Figure 7—*Lepidocampa giffardii* Silvestri. (Abernathy drawing. Cerci broken.)

Family **JAPYGIDAE** Lubbock, 1873

Body without scales; antennae with a variable number of segments (38- and 18-segmented in the Hawaiian species); mandibles consisting of a single dentate sclerite with one articulation with the head; maxillary palpi reduced; labial palpi wanting in *Parajapyx*, single-segmented in *Japyx*; abdominal ventrites one to seven with styli, second ventrite only with protrusible vesicles, but with a specialized organ on either side of the first ventrite and a specialized glandular organ between these on some species; cerci heavily sclerotized forceps.

A group of blind, evidently predaceous, soil-inhabiting insects which, because of their forceps-like cerci, might easily be confused with earwigs. Our species are medium-sized insects (up to 10 mm. in length), but in Australia the largest size of any living apterygotan insect is attained by some giant members of the genus *Heterojapyx* which may be 50 mm. long.

Only two species have been recorded in Hawaii, but there are other undetermined species here. Our species may be placed in two subfamilies as follows (the number of antennal segments applies only to the two species thus far recorded from the islands and probably will have to be revised when additional species are recorded):

KEY TO THE SUBFAMILIES OF JAPYGINAE

1. Antennae with less than 20 segments, without specialized sensory setae on any of the segments..... **Parajapyginae.**
2. Antennae with more than 30 segments, with differentiated, specialized sensory setae on segments four, five and six  
..... **Japyginae.**

Subfamily PARAJAPYGINAE

Genus **PARAJAPYX** Silvestri, 1903

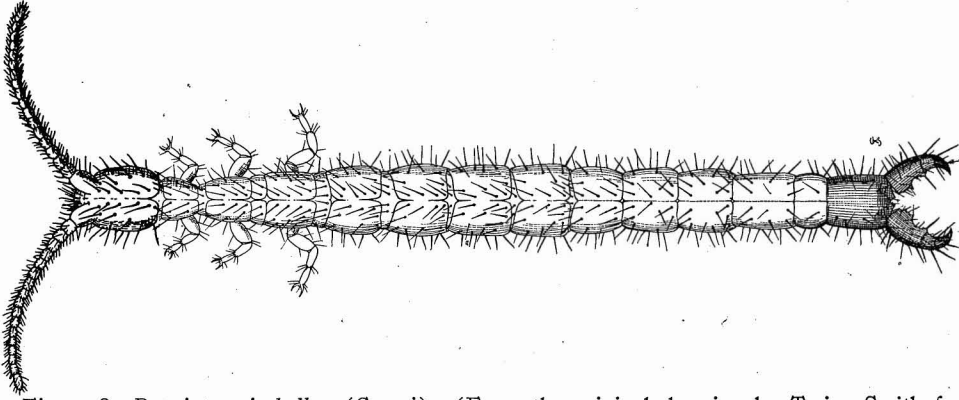


Figure 8—*Parajapyx isabellae* (Grassi). (From the original drawing by Twigg-Smith for Williams, 1931.)

**Parajapyx isabellae** (Grassi) (fig. 8).

*Japyx isabellae* Grassi, 1886:1-13.

*Japyx minimus* Swenk, 1903:131, fig. 1.

Silvestri, 1928:79, figs. XX-XXI. Williams' (1931:351) fig. 178 is of this species.

Kauai, Oahu, Maui, Hawaii.

Immigrant. Europe (type from Sicily), China, Japan, North America. First recorded under this name from Hawaii by Van Zwaluwenburg in 1934, but known here previously as an unidentified japygid.

Abundant in soil in lowlands (from a few to over 200 individuals per square foot several inches below the surface in some places). Van Zwaluwenburg (in Williams, 1931:350) notes that this species in captivity "rasps irregular wounds in tender root cortex," but no further data on the food habits of the genus are known to me.

Subfamily JAPYGINAE

Genus **JAPYX** (Haliday)

*Japyx* Haliday, 1864.

**Japyx sharpi** Silvestri (fig. 9).

*Japyx sharpi* Silvestri, 1904:293, pl. 8, figs. 1-8.

Kauai (type material from Kaholuamano and Halemanu).

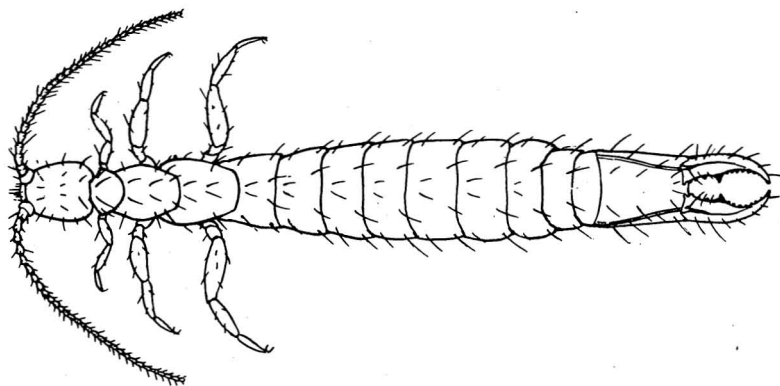


Figure 9—*Japyx sharpi* Silvestri. (Abernathy drawing.)

Immigrant. Source undetermined.

Found in rotting logs, under logs, and in soil. No study has been made of this species, and I have only one record of its capture since the type series was collected by Perkins.

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The bibliography for this order is incorporated at the end of the Collembola section (p. 69).

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## Order **PROTURA** Silvestri, 1907

(*pro*, primitive; *oura*, tail)

### Proturans

Mouth parts entognathous, of the piercing type, stylet-like; antennae absent; eyes absent; with "pseudocelli"; maxillary palpi three- or four-segmented, fitted for piercing; labial palpi two- or three-segmented; tarsi single-segmented, claws single; abdomen 12-segmented in adult, ventrites one to three with specialized sublateral appendages; cerci and caudal appendages absent; genital opening between segments 11 and 12; metamorphosis slight, consisting of the addition of three post-embryonic segments between the eighth and twelfth segments by anamorphosis.

This is a group of peculiar, minute (less than 2 mm. long), pale insects without apparent close living allies. They have been placed in a class of their own (Myrientomata) by some authors who argue that they are not insects. However, the evidence now at hand appears to support the contention that they are primitive, aberrant insects.

The Hawaiian material has not yet been identified. Van Zwaluwenburg collected the first specimens found in the islands in soil from sugarcane fields near Honolulu in 1933. He has subsequently found them in soil at different localities up to elevations of 1,000 feet on Oahu.



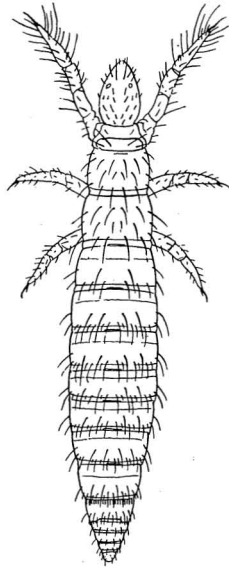


Figure 10—A typical proturan, *Acerentulus barberi barberi* Ewing. (Redrawn from Ewing, 1940:497. This species is not known to occur in Hawaii, but, because no local material is available, the drawing of the American species is used here to illustrate the Protura.)

The families are separated by Ewing (1940:517) as follows:

1. Tracheae present, opening through two pairs of spiracles, one on mesothorax and one on metathorax; all vestigial abdominal appendages two-segmented ..... **Eosentomidae.**
2. Tracheae and spiracles absent; third vestigial abdominal appendages single-segmented ..... **Acerentomidae.**

Ewing's paper (1940) should be consulted by anyone wishing to work on this group, for it gives methods of collecting and preservation as well as a general discussion of the order.

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The literature on this chapter is included in the bibliography at the end of the Collembola section (p. 69).

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## Order COLLEMBOLA Lubbock, 1873

(*colla*, glue; *embolon*, a bar—referring to the ventral “adhesive” organs)

### Collembolans, Springtails

Small to minute, soft-bodied, jumping insects mostly less than 5 mm. long; body variform, setose or squamose; head with entognathous mouth parts; labrum and clypeus present; mandibles present or absent—if present, slender or styliform, fitted for piercing and sucking or for chewing and then with incisor and usually

molar areas; maxillae with specialized dentate apex or styliform; maxillary palpi reduced or vestigial; labrum greatly reduced, labial palpi absent in adults; antennae four- to six-segmented, length variable, shorter than head to longer than body; compound eyes absent; with or without a group of ocelli at sides of head behind antennae, with a maximum number of eight ocelli in a group; most forms with a specialized sensory structure, the *postantennal organ*, situated behind each antenna; thorax variform, with segmentation distinct or ankylosed, or with prothorax much reduced, its notum obscure, the other segments distinct; legs evidently without tarsi, tibiae (tibio-tarsi) terminating in one or two claws (when two are present, they oppose vertically instead of horizontally); abdomen with not more than six segments, some or all of the segments ankylosed in some forms; first ventrite with a median bilobed organ, the *ventral tube*, containing protrusible vesicles; third ventrite usually with a bipartite median appendage, the catch or *tenaculum* (*retinaculum*), on which the furcula is held when at rest; fourth ventrite, on most forms, bearing the leaping organ, or *furcula*, composed of a pair of organs fused basad to form the *manubrium*, bifurcate distad to form a pair of *dentes* each terminating in a small *mucro*; cerci absent; genital opening on the caudal edge of the fifth ventrite, without external genitalia; metamorphosis slight.

Some authorities believe that the Collembola are not true insects and that they have had an independent origin from a pre-insect type of arthropod.

Springtails are among the most widespread of all insects, and are found throughout the world from north to south polar regions. They are hydrophiles found most everywhere in damp situations from ocean beach to mountain top, in soil, caves, tunnels, graves, under stones and logs, in ground surface litter, in moss and lichens, under bark, in rotting wood, in shrubbery, high up in trees, and some species are even found in great numbers on the surface of snow and on bodies of water; some are termitophiles and others myrmecophiles.

The food habits vary, some are carnivores or scavengers; others are phytophagous and feed on living and dead plant material; some are fungivorous. They are among the most important organisms in returning dead vegetable matter to the soil. Among the phytophagous species, some are of considerable economic importance in certain regions. *Sminthurus viridis*, the "lucerne flea" of Australia, for example, has received much attention because of the great damage it does to leguminous and other plants, and a large body of literature has been built up about its habits. It is considered by some workers as probably the most serious insect pest of pastures in parts of Australia where, according to Womersley (1939), infestations may run as high as 6,000 individuals per square foot of pasture. It feeds on the leaves of such plants as alfalfa (lucerne) and causes severe skeletonization. An interesting research report on the serious damage done to mangold seedlings by *Bourletiella hortensis* in England is that by Davies (1926:159). We have at least one species of the same genus in Hawaii. At least one of the species found in Hawaii (*Isotomodes denisi* Folsom) has been estimated to total more than one hundred million individuals to the acre. This same insect has been shown to cause damage to the rootlets of sugarcane by gnawing small holes in them, thus

retarding root growth with a subsequent detrimental stunting effect on the cane (Van Zwaluwenburg, in Williams, 1931:348). However, it was demonstrated experimentally that the insects are principally humus feeders and damage to the cane is negligible in soils containing a large amount of decaying organic matter. Sugarcane seedlings in flats containing little humus are likely to be attacked. Williams (1931:49) recommends pyrethrum at the concentration of 1 part per 200 parts of water as a satisfactory control spray. Only on rare occasions have these insects caused serious damage to Hawaiian crops. On Oahu, collembolans have been seen piled up in great masses in windrows along the edges of rows of pine-apples. Womersley (1939:276) gives a list of all the species recorded as injurious to crops up to 1939; the list contains 69 names.

At least one species has been utilized by man. That species is *Achorutes (Hypogastrura) viatica* (Tullberg), which is used in England for cleaning the filters of sewage disposal plants.

Numerous predators such as ants and spiders are known to attack Collembola. In Australia a mite has aided in the control of the "lucerne flea" (an alfalfa pest). However, no arthropod parasites are known to attack these primitive insects.

Fossil Collembola are known from Cretaceous Canadian amber, which has disclosed the peculiar family Protentomobryidae, and from Oligocene Baltic amber, from which representatives of the families Poduridae and Sminthuridae have been described. Fossilization of such delicate, soft-bodied organisms is of rare occurrence. Tillyard described what he considered to be Collembola from Scottish Devonian deposits, but later workers appear not to have accepted his conclusions. However, Hirst and Maulik have described a species from Middle Devonian Scottish deposits which is said not to differ from living forms, but there is still a question of their true identity.

Because the Collembola as a whole are such an incompletely known group, it is not possible at this time to assign any of the species found in Hawaii to the endemic Hawaiian fauna. More than 20 species and two genera have been described from Hawaii, but with the great ease that species of this order are carried about the world by commerce, we cannot be sure that any of these species are other than immigrants which may ultimately be found indigenous to other geographical regions. None of the Hawaiian species appears to be so peculiar or so unusually isolated as to indicate probable endemism. Also, there has not yet been found in the islands a species complex of Collembola which can be compared with other such endemic groups which are so characteristic of most of the endemic Hawaiian insects of other orders. In spite of the apparent absence of the order from the native fauna, the group is a dominant one in Hawaii, and individuals may be found almost everywhere in the islands. Often, as this book was being written, trade winds have blown small species through the open window and onto my desk. Further detailed study and careful collecting in the forests may, however, reveal endemic species, since no obvious reason is seen for the complete exclusion of the order from the endemic fauna. Insofar as I know, the life history of none of the species has been studied in detail in Hawaii.

## TABULAR ANALYSIS OF HAWAIIAN COLLEMBOLA

FAMILY	GENERA	ENDEMIC GENERA	NON-ENDEMIC GENERA	SPECIES	ENDEMIC SPECIES	ADVENTIVE SPECIES
Achorutidae	5	0	5	6	0(1?)	6(5?)
Onychiuridae	2	0	2	2	0	2
Isotomidae	7	0	7	8	0(1?)	8(7?)
Entomobryidae	7	0	7	13	0(3?)	13(10?)
Sminthuridae	3	0	3	3	0	3
Totals	24	0	24	32	0(5?)	32(27?)

Percentage of present-day fauna native: 0 percent (or 15.6 percent ?).

Percentage of present-day fauna adventive: 100 percent (or 84.4 percent ?).

Average number of species per genus: 1.3.

Our knowledge of the Collembola from a world-wide standpoint is still too meager to enable us to ascertain whether or not any of the species, which from their habit might possibly be native, are or are not indigenes. Five species fall in this "possibly native" category.

Two taxonomic papers constitute the literature pertaining to the species described from Hawaii. These are Carpenter's report in *Fauna Hawaiiensis* in 1904 and Folsom's revision in 1932. We are fortunate in having Folsom's carefully written revision as a background for further work. For most of the generic and specific categories, I have followed Folsom's report, and most of the keys contained hereinafter are abstracted, reworded or revised from Folsom's originals, and to him belongs the credit for them. However, for the suprageneric classification, I have followed the more recent work of Womersley (1939) which differs somewhat from that of Folsom, and I have incorporated some of his key material in the generic and suprageneric keys. We were fortunate in having Folsom's original drawings preserved in Honolulu, and I have rearranged these and reproduced them here. Except for a couple of my sketches, the illustrations used here are from Folsom's report, unless otherwise indicated.

There are many more species of Collembola in Hawaii than those listed hereinafter—perhaps only a lesser fraction of the species now present in the islands has been recorded—and when more of them are described or identified, modifications of the keys will be required.

In spite of the small size and cryptic habits of most of the species, many are beautifully colored and peculiar in shape and structure.

## KEY TO THE SUBORDERS OF COLLEMBOLA

1. Abdomen elongate, subcylindrical, segmentation distinct, thorax and abdomen not fused; elongate insects.....**Arthropleona.**
2. Abdomen conspicuously globular or inflated, not obviously segmented, the segments fused, their sutures obliterated or obscure, thorax and first four abdominal segments fused; subglobose insects .....**Symphyleona.**

## Suborder ARTHROPLEONA Börner, 1901

## KEY TO THE SUPERFAMILIES

1. Prothorax distinct and visible from above, well-developed, with a distinct tergum and with dorsal setae; furcula, when present, arising from fourth ventrite; antennae short, usually shorter than length of head, four-segmented; derm granular or tuberculate, not squamose.....**Poduroidea.**
2. Prothorax very small, hidden from above, without a distinct tergum, without dorsal setae; furcula, when present, apparently arising from fifth ventrite (actually arising from fourth); antennae four- to six-segmented, often longer than head and thorax; derm smooth, hirsute or squamose.....**Entomobryoidea.**

## Superfamily PODUROIDEA Womersley, 1939

## KEY TO THE FAMILIES FOUND IN HAWAII

1. Tergites of thorax and abdomen without pseudocelli...**Achorutidae.**
2. Tergites of thorax and abdomen with pseudocelli...**Onychiuridae.**

## Family ACHORUTIDAE

*Hypogastruridae* Börner, 1913

## KEY TO THE SUBFAMILIES

1. Mouth parts not projecting in a cone; mandibles with a molar area.....**Achorutinae.**
2. Mouth parts projecting into a cone in most genera; mandibles without a molar area.....**Neanurinae.**

## Subfamily ACHORUTINAE Börner, 1901

## KEY TO THE GENERA FOUND IN HAWAII

1. Postantennal organs present; eight ocelli on each side; furcula well-developed.....**Achorutes** subgenus **Schöttella** Schaeffer.
2. Postantennal organs absent; five ocelli on each side; furcula reduced, dens and mucro not or feebly separated.....**Xenylla** Tullberg.

## Genus ACHORUTES Templeton, 1835

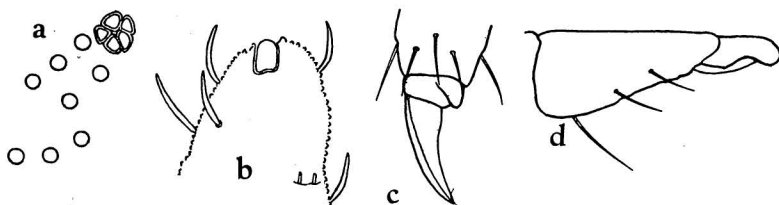
*Hypogastrura* Bourlet, 1839

Figure 11—*Achorutes* (*Schöttella*) *alba* (Folsom): a, eyes and postantennal organ of right side; b, dorsal aspect of apex of right antenna; c, right hind foot; d, right dens and mucro.

Subgenus *Schöttella* Schaeffer, 1897**Achorutes** (*Schöttella*) *alba* (Folsom) (fig. 11, a-d).*Schöttella alba* Folsom, 1932:54, pl. 1, figs. 1-4.

Oahu (type locality: Honolulu).

Immigrant.

In soil about pineapple roots.

Genus **XENYLLA** Tullberg, 1869

## KEY TO THE SPECIES FOUND IN HAWAII

1. White species; unguis simple; sensory organ of third antennal segment without papillae between the horn-like processes ..... *alba* Folsom.
2. Body mottled with blue above; unguis dentate; sensory organ of third antennal segment with a pair of clavate papilla-like organs between two horn-like processes..... *sensilis* Folsom.

***Xenylla alba*** Folsom (fig. 12, a-g).*Xenylla alba* Folsom, 1932:54, pl. 2, figs. 14-20.

Oahu (type locality: Honolulu).

Immigrant.

In soil of pineapple fields.

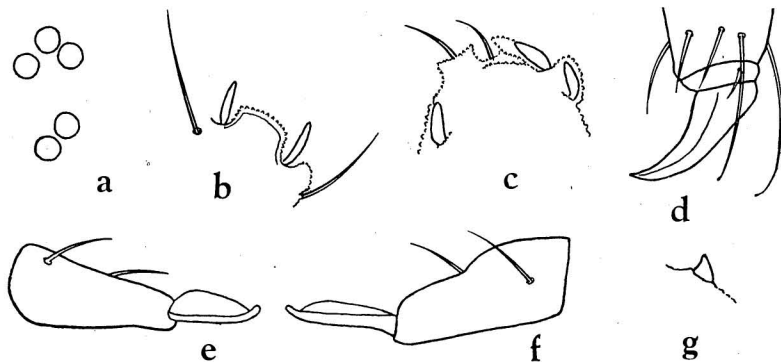


Figure 12—*Xenylla alba* Folsom: a, right eyes; b, antennal sense organ of right third antennal segment; c, dorsal aspect of apex of right antenna; d, right hind foot; e, left dens and mucro; f, right dens and mucro; g, anal spine.

***Xenylla sensilis*** Folsom (fig. 13, a-i).*Xenylla sensilis* Folsom, 1932:54, pl. 1, figs. 5-13.

Oahu (type locality: Honolulu).

Immigrant.

In soil of pineapple fields.

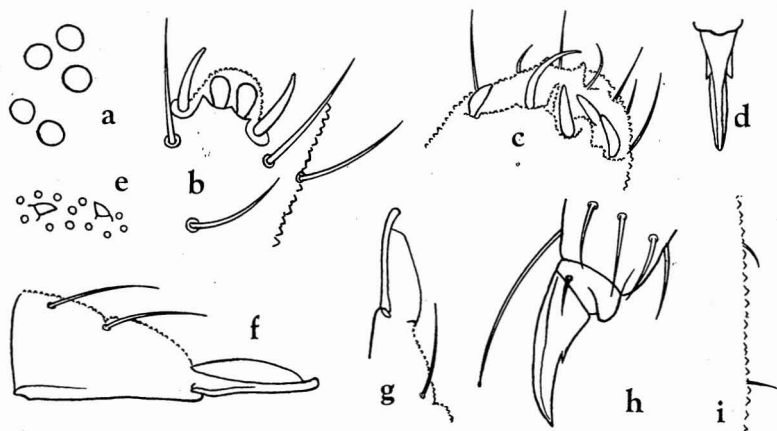


Figure 13—*Xenylla sensilis* Folsom: a, left eyes; b, sense organ of third antennal segment of right side; c, apex of right antenna, dorsal aspect; d, concave aspect of unguis; e, anal spines; f, left dens and mucro; g, right mucro; h, right fore foot; i, dorsal setae of metanotum.

#### Subfamily NEANURINAE Börner, 1901

##### KEY TO THE TRIBES

1. Body without segmental tubercles; anal segment comparatively small; supra-anal valve rounded, not bilobed... **Pseudachorutini.**
2. Body with large segmental tubercles; anal segment comparatively large; supra-anal valve bilobed..... **Neanurini.**

#### Tribe PSEUDACHORUTINI Börner, 1906

##### Genus **STACHIA** Folsom, 1932:55

#### **Stachia minuta** Folsom (fig. 14, a-j).

*Stachia minuta* Folsom, 1932:55, pl. 2, figs. 21–26; pl. 3, figs. 27–30. Genotype. Oahu (type locality).

Immigrant.

Widespread in soil in pineapple and sugarcane fields and lower forests.

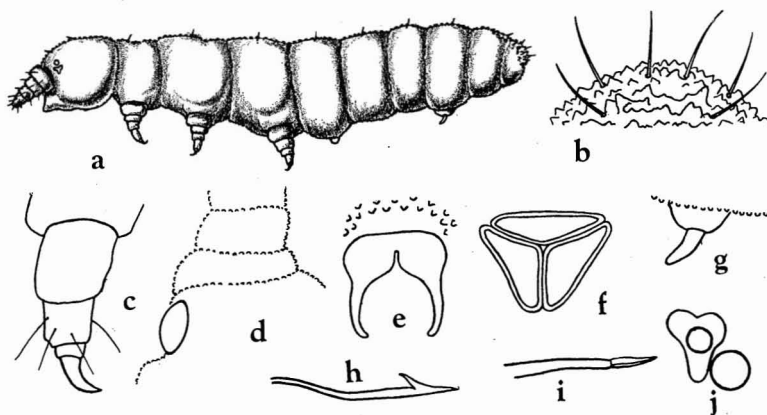


Figure 14—*Stachia minuta* Folsom: a, lateral view; b, anal segment, dorsal aspect; c, end of left fore foot; d, left eye and base of antenna; e, furcula, dorsal aspect; f, suranal and subanal valves; g, furcula, left aspect; h, mandible; i, maxilla; j, left eye and postantennal organ.

## Tribe NEANURINI Börner

## KEY TO THE GENERA FOUND IN HAWAII

1. Head of maxilla with toothed lamellae; ocelli and postantennal organs absent in our species.....**Protanura** Börner.
2. Head of maxilla stylet-like, without lamellae or teeth; ocelli present and postantennal organs present but reduced in our species .....**Neanura** MacGillivray.

Genus **PROTANURA** Börner, 1906

**Protanura capitata** Folsom' (fig. 15, a-f).

*Protanura capitata* Folsom, 1932:56, pl. 3, figs. 31-36.

Oahu (type locality: Honolulu).

Immigrant.

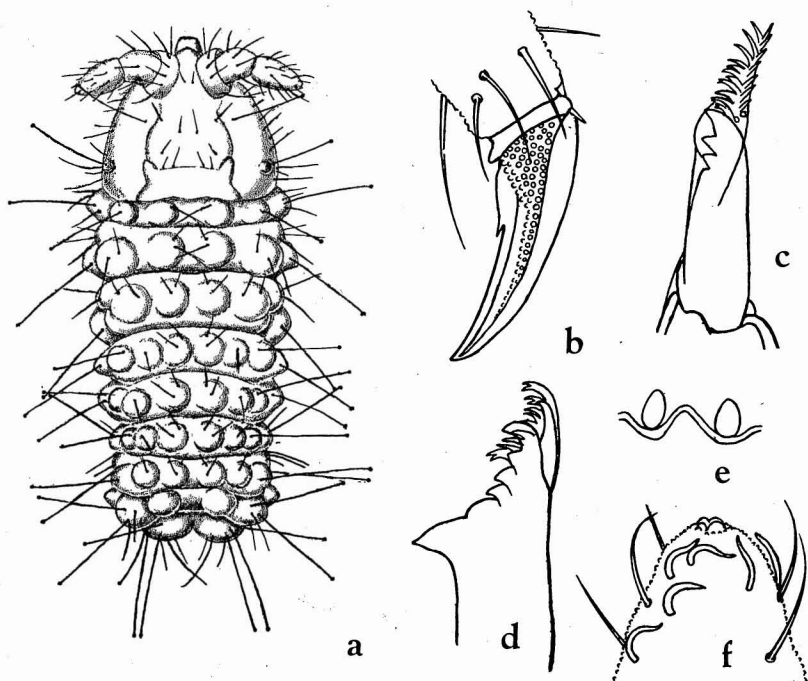


Figure 15—*Protanura capitata* Folsom: a, dorsal aspect; b, left hind foot; c, head of right maxilla; d, head of right mandible; e, sense organ of third antennal segment of right side; f, dorsal aspect of end of right antenna.

Genus **NEANURA** MacGillivray, 1893

**Neanura citronella** Carpenter.

*Neanura citronella* Carpenter, 1904:303, pl. 9, figs. 20-27.

Oahu, Maui (no more specific type locality given).

Immigrant(?).

Beneath bark of *Acacia koa*, *Gunnera*.



## Family ONYCHIURIDAE Lubbock, 1867

## KEY TO THE SUBFAMILIES

1. Body stout; head broad; postantennal organ in our species with less than 20 tubercles, which are branched; large sensory clubs of organ of third antennal segment smooth or tuberculate, but not bending toward each other.....**Onychiurinae**.
2. Body slender; head narrow; postantennal organ in our species with about 60 tubercles; large sensory clubs of organ of third antennal segment smooth, bent toward each other...**Tullberginae**.

Subfamily ONYCHIURINAE Bagnall, 1935

Genus **ONYCHIURUS** Gervais, 1841**Onychiurus fimetarius** (Linnaeus) (fig. 16, a-f).*Podura fimetaria* Linnaeus, 1758:609.

Lubbock, 1873:191, pl. 47. See Folsom, 1917:649, pl. 69, fig. 9; pl. 77, figs. 83-86; pl. 78, figs. 87-88, for detailed synonymy and description.

Hawaii.

Immigrant. Cosmopolitan. First recorded in Hawaii by Folsom (1932:57).

In sugarcane fields; probably common also in humus, piles of leaves, under bark and logs and in other situations.

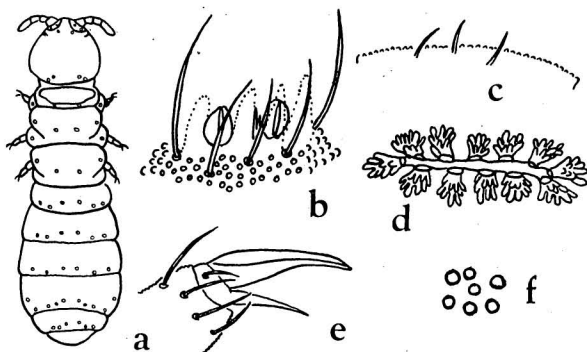


Figure 16—Details of *Onychiurus fimetarius* (Linnaeus); a, dorsal aspect; b, left antennal sense organ; c, vestiture on median line of first abdominal segment; d, right postantennal organ; e, right hind foot; f, cuticular tubercles of head. (Redrawn from Folsom, 1917.)

Subfamily TULLBERGINAE Bagnall, 1935

Genus **TULLBERGIA** Lubbock, 1876**Tullbergia silvicola** Folsom (fig. 17, a-e).*Tullbergia silvicola* Folsom, 1932:57, pl. 4, figs. 37-41.

Oahu (type from Mount Tantalus, 1,700 feet).

Immigrant.

In soil in lower forest.

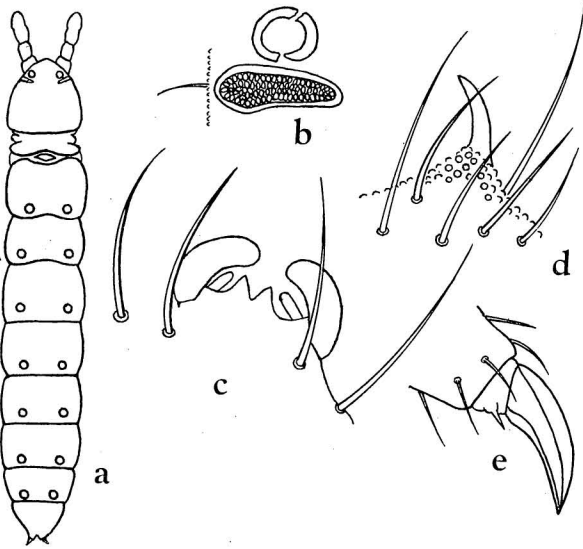


Figure 17—*Tullbergia silvicola* Folsom: a, dorsal aspect; b, left postantennal organ and pseudocellus; c, sense organ of third antennal segment of right side; d, left anal spine; e, left hind foot.

## Superfamily ENTOMOBRYOIDEA Womersley, 1939

*Entomobryomorpha* Börner, 1913

### KEY TO THE FAMILIES FOUND IN HAWAII

1. Postantennal organs present in all of our species except *Isotoma minor*; fourth abdominal segment not much longer than third; inner margin of unguis simple, not split into two lamellae; squamae never present; body setae simple or at most plumose on one side only; hind coxae without a specialized setose area ..... **Isotomidae.**
2. Postantennal organs absent; fourth abdominal segment much longer than third; inner margin of unguis split or proximally grooved; squamae present or absent; body setae of various types but including some plumose or ciliated on all sides; hind coxae with a specialized setose or hirsute area. . . . **Entomobryidae.**

Family ISOTOMIDAE Schaeffer, 1896

Subfamily ISOTOMINAE Schaeffer, 1898

### KEY TO THE GENERA FOUND IN HAWAII

1. Body cylindrical, greatly elongate; prothorax elongate. . . . . 2  
Body not greatly elongate; prothorax more or less reduced. . . . . 3
- 2(1). Derm granulate; all abdominal segments distinct, terminal ones not fused; manubrial hooks not strongly developed; one or two ocelli on each side. . . . . **Folsomides** Stach.  
Derm smooth; abdominal segments four to six fused or at least with segment six shortened and modified; manubrial hooks strongly developed; ocelli absent. . . **Isotomodes** Axelson.

- 3(1). Eyes reduced in number or absent; caudal three abdominal segments fused into a single mass; body pigmentation weak or wanting..... 4  
 Usually with 16 eyes; three terminal abdominal segments not fused; body pigmentation usually well-developed..... 5
- 4(3). Mucro bidentate; fourth antennal segment without sensory clavae; postantennal organs present..... **Folsomia** Willem.  
 Mucro falciform; fourth antennal segment with five or six large, sensory clavae; postantennal organs absent..... **Denisia** Folsom.
- 5(3). Third abdominal tergite shorter than fourth, not prolonged ventrolaterally caudad; furcula not reaching ventral tube..... **Proisotoma** Börner.  
 Third abdominal tergite longer than fourth, ventrolaterally prolonged caudad; furcula reaching ventral tube..... 6
- 6(5). Mucrones lamellate; abdomen with fringed bothriotrichia..... **Isotomurus** Börner.  
 Mucrones not lamellate; abdomen without bothriotrichia..... **Isotoma** Bourlet.

Genus **FOLSOMIDES** Stach, 1922

**Folsomides exiguus** Folsom (fig. 18, a-f).

*Folsomides exiguus* Folsom, 1932:58, pl. 4, figs. 42-47.

Oahu (type locality).

Immigrant.

In soil in sugarcane fields, rice fields and lower forest.

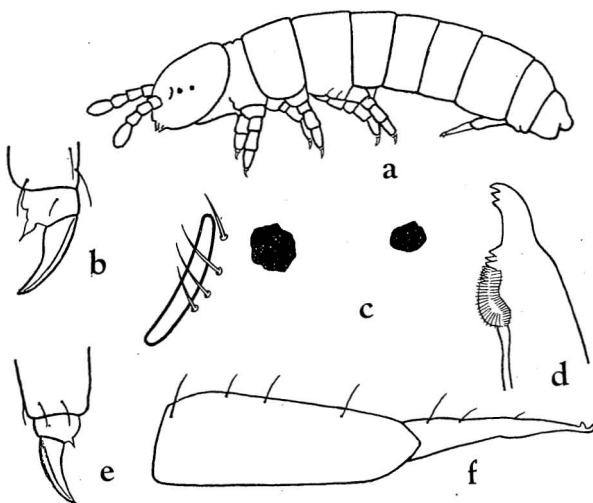


Figure 18—Details of *Folsomides exiguus* Folsom: a, lateral aspect; b, left hind foot; c, eyes and postantennal organ of left side; d, mandible; e, right fore foot; f, left aspect of manubrium and mucrodens.

Genus **ISOTOMODES** Axelson, 1907**Isotomodes denisi** Folsom (fig. 19, a-i).*Isotomodes denisi* Folsom, 1932:59, pl. 5, figs. 48-56.

Oahu, Hawaii (no specific type locality given).

Immigrant.

In soil of sugarcane fields and lower forest.

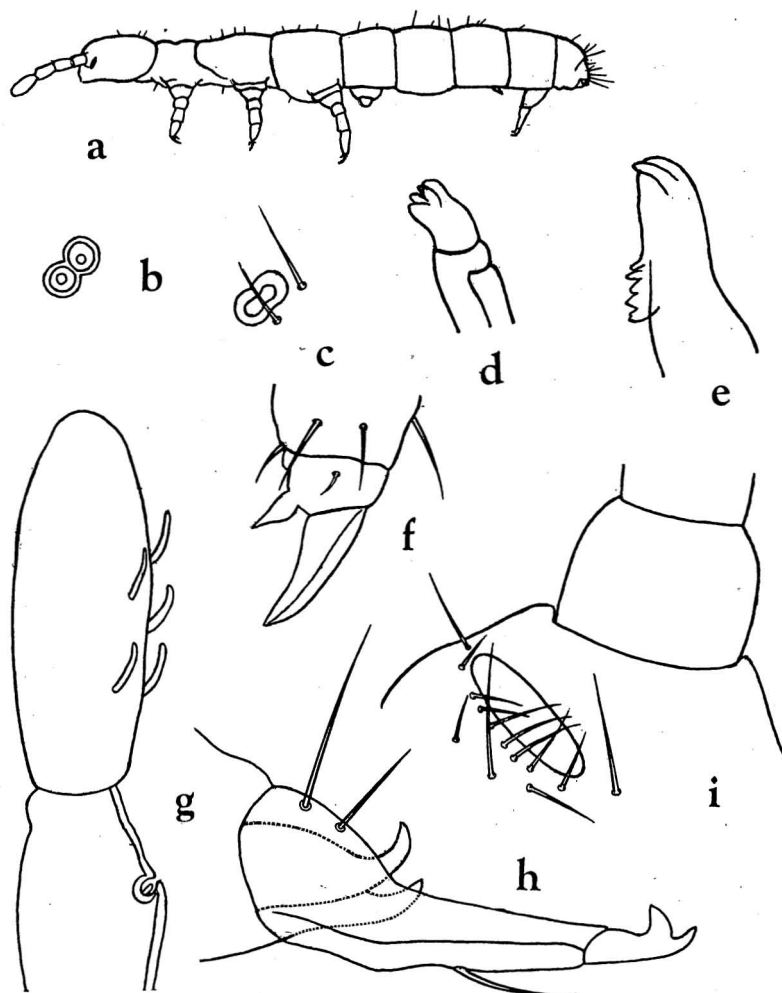


Figure 19—Details of *Isotomodes denisi* Folsom: a, lateral aspect; b, sense organ of third antennal segment of left side in optical cross section; c, the same, surface aspect; d, head of maxilla; e, head of mandible; f, left hind foot; g, ventral aspect of extremity of left antenna; h, left dens and mucro; i, left postantennal organ and base of antenna.

Genus **FOLSOMIA** Willem, 1902**Folsomia fimetaria** (Linnaeus).

*Podura fimetaria* Linnaeus, 1761:474. See Folsom, 1902:92, pl. 7, figs. 37–39, for re-description and synonymy.

Hawaii.

Immigrant. Cosmopolitan. First recorded in Hawaii by Folsom (1932:60).

In sugarcane soil.

Recorded elsewhere as causing serious injury to plant rootlets (Womersley, 1939:145). A common species elsewhere in soil, humus, potted plants, under logs and in similar conditions and probably with the same habits in Hawaii.

Genus **DENISIA** Folsom, 1932:61

Womersley (1939:137) includes this genus with *Folsomina* Denis.

**Denisia falcata** Folsom (fig. 20, a–f).

*Denisia falcata* Folsom, 1932:61, pl. 5, fig. 57; pl. 6, figs. 58–62. Genotype.

Oahu (type locality: Honolulu).

Immigrant.

In sugarcane soil and in debris from nest of the ground-dwelling termite, *Coptotermes formosanus* Shiraki.

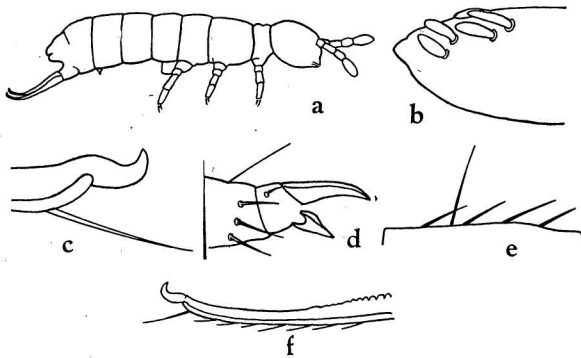


Figure 20—Details of *Denisia falcata* Folsom: a, lateral aspect; b, lateral aspect of extremity of left antenna; c, left mucro; d, left hind foot; e, vestiture on second abdominal segment; f, right mucro and part of dens.

Genus **PROISOTOMA** Börner, 1906**Proisotoma nigromaculosa** Folsom (fig. 21, a–d).

*Proisotoma nigromaculosa* Folsom, 1932:62, pl. 6, figs. 63–66.

Oahu (type locality).

Immigrant.

In soil of sugarcane and rice fields.

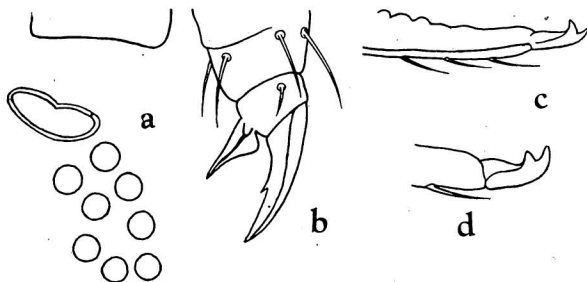


Figure 21—*Proisotoma nigromaculosa* Folsom: a, eyes, postantennal organ and base of antenna of left side; b, right hind foot; c and d, left mucro.

### Genus **ISOTOMURUS** Börner, 1903

#### **Isotomurus palustris balteatus** (Reuter).

*Isotoma balteata* Reuter, 1876:86.

*Isotomurus palustris* variety *balteatus* (Reuter) Schött, 1893:66, pl. 5, fig. 10.

Kauai, Oahu.

Immigrant. Europe, America, Australia, Bismarck Archipelago. First recorded in Hawaii by Folsom (1932:63).

Beneath trash; in soil of sugarcane fields.

### Genus **ISOTOMA** Bourlet, 1839

#### KEY TO THE SPECIES FOUND IN HAWAII

1. Body white; without ocelli, postantennal organs or tenent hairs  
..... **minor** Schaeffer.
2. Body purplish yellow; eight ocelli on each side; postantennal  
organs present; one tenent hair present..... **perkinsi** Carpenter.

#### **Isotoma minor** Schaeffer (fig. 22, a-e).

*Isotoma minor* Schaeffer, 1896:182. Folsom, 1932:63, pl. 6, figs. 67-71, re-description.

Oahu.

Immigrant. Europe, North America, Central America. First recorded from Hawaii by Folsom (1932:63).

In soil of sugarcane fields.

#### **Isotoma perkinsi** Carpenter.

*Isotoma perkinsi* Carpenter, 1904:302, pl. 9, figs. 17-19.

Kauai (type locality: Kaholuamano).

Immigrant(?).

No records are available other than from the unique type.

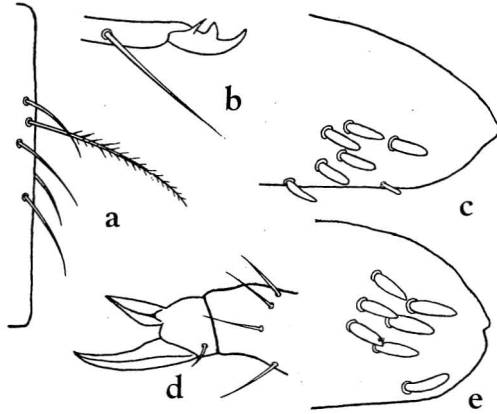


Figure 22—*Isotoma minor* Schaeffer: a, dorsal setae of second abdominal segment; b, left mucro; c and e, apex of left antenna; d, left hind foot.

### Family ENTOMOBRYIDAE Börner, 1913

#### KEY TO THE SUBFAMILIES

1. Dentes slender, dorsally annulated, tapering to small mucrones;  
mucro short, small.....**Entomobryinae.**  
Dentes not annulated dorsally, blunt, with large mucrones..... 2
2. Antennae longer than entire body; ocelli present; dentes without  
dorsal squamae; mucro robust with dissimilar inner and outer  
margins; our species yellow with purple maculations. **Paronellinae.**  
Antennae shorter than body; ocelli absent; dentes with two  
dorsal rows of feather-like squamae; mucro elongate, slender,  
margins similar; our species white.....**Cyphoderinae.**

#### Subfamily ENTOMOBRYINAE Börner, 1906

##### Tribe ENTOMOBRYINI Börner, 1906

#### KEY TO THE GENERA FOUND IN HAWAII

1. Body not squamose ..... 2  
Body squamose ..... 3
- 2(1). Tarsal claws each with a large, inner, wing-like, basal tooth;  
tenent hair of tibio-tarsus weakly developed; with a double  
row of smooth, pointed bristles on inner face of tibio-  
tarsus ..... **Sinella** Brook.  
Inner basal teeth of tarsal claws simple; tenent hair of tibio-  
tarsus strongly developed, without such a double row of  
smooth, pointed bristles on inner face of tibio-tarsus  
..... **Entomobrya** Rondani.
- 3(1). Squamae apically pointed, with long, coarse striae; dentes  
not squamose ..... **Sira** Lubbock.  
Squamae apically rounded, with short, fine, close striae;  
dentes squamose ..... 4
- 4(3). Mucro with two teeth and a basal spine... **Lepidocyrtus** Bourlet.  
Mucro falciform ..... **Drepanocyrtus** Handschin.

Genus **SINELLA** Brook, 1882

**Sinella caeca** (Schött) (fig. 23, a-c).

*Entomobrya caeca* Schött, 1896:178, pl. 1, figs. 14-16.

*Sinella höfti* Schaeffer, 1897:192. Folsom, 1932:66, pl. 7, figs. 79-81.

*Sinella tenebricosa* Folsom, 1902:365, figs. 11-14.

Oahu.

Immigrant. Eurasia, Australia. First recorded from Hawaii by Folsom (1932:66).

In soil, lower forest.

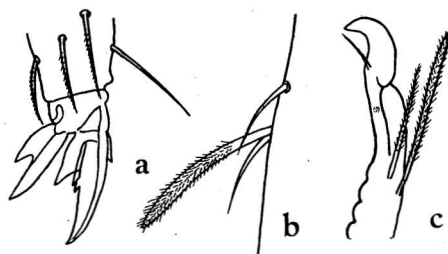


Figure 23—*Sinella caeca* (Schött): a, right hind foot; b, subclavate seta of hind tibiotarsus; c, left mucro and end of dens.

Genus **SIRA** Lubbock, 1869

**Sira jacobsoni** Börner (fig. 24, a-g).

*Sira jacobsoni* Börner, 1913:49, fig. 4. Folsom, 1932:66, pl. 8, figs. 82-88.

*Sira tricincta* Schött, 1917:31, fig. 37.

Oahu.

Immigrant. Java, New Guinea, Sunda Islands, Australia. First recorded from Hawaii by Folsom (1932:66) from specimens collected in 1928.

In soil of pineapple fields; in rice straw.

Genus **ENTOMOBRYA** Rondani, 1861

## KEY TO THE SPECIES FOUND IN HAWAII

1. Entirely white species.....**lactea** Folsom.  
Yellow with purple markings..... 2
- 2(1). Transversely banded.....**multifasciata imminuta** Folsom.  
Not transversely banded..... 3
- 3(2). Yellow with purple lateral stripes; mucro with basal tooth  
.....**insularis** Carpenter.  
Yellow with confused purple markings; mucro without basal  
tooth .....**kalakaua** Carpenter.



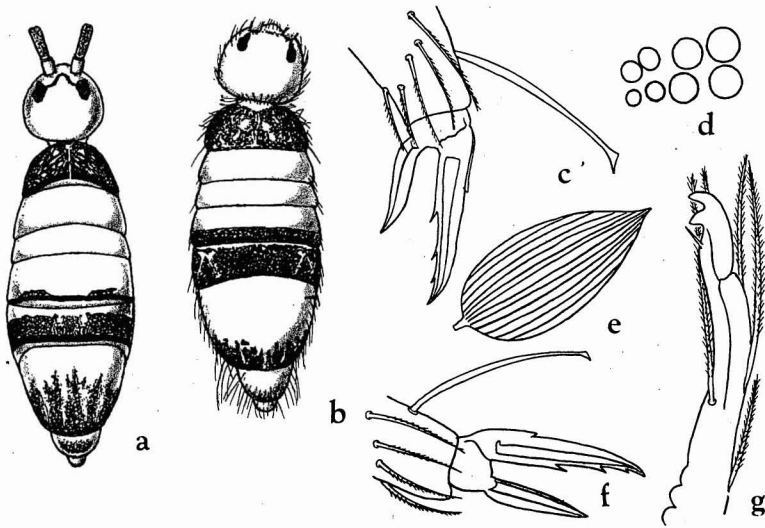


Figure 24—*Sira jacobsoni* Börner: a and b, dorsal aspects to show variation in color pattern; c and f, right middle foot; d, eyes of left side; e, body scale; g, left mucro and end of dens.

***Entomobrya insularis* Carpenter.**

*Entomobrya insularis* Carpenter, 1904:301, pl. 9, figs. 7–11.

Hawaii (type locality).

Immigrant(?).

***Entomobrya kalakaua* Carpenter.**

*Entomobrya kalakaua* Carpenter, 1904:301, pl. 9, figs. 12–16.

Kauai (unique type from Kaholuamano).

Immigrant(?).

***Entomobrya lactea* Folsom (fig. 25, a–d).**

*Entomobrya lactea* Folsom, 1932:65, pl. 7, figs. 76–78.

Oahu (type locality: Honolulu).

Immigrant.

Behind sugarcane leaf sheaths; in trash.

***Entomobrya multifasciata imminuta* Folsom (fig. 26, a–d).**

*Entomobrya multifasciata* variety *imminuta* Folsom, 1932:64, pl. 7, figs. 72–75.

Oahu (type locality: Pupukea).

Immigrant (the typical variety is almost cosmopolitan).

In soil of pineapple fields. Evidently fungivorous.

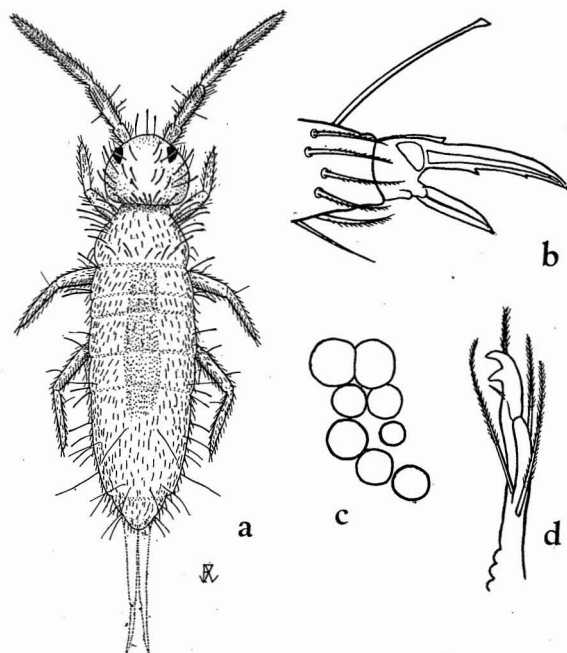


Figure 25—*Entomobrya lactea* Folsom: a, dorsal aspect; b, left hind foot; c, eyes of left side; d, left mucro and end of dens. (a, after Williams, 1931.)

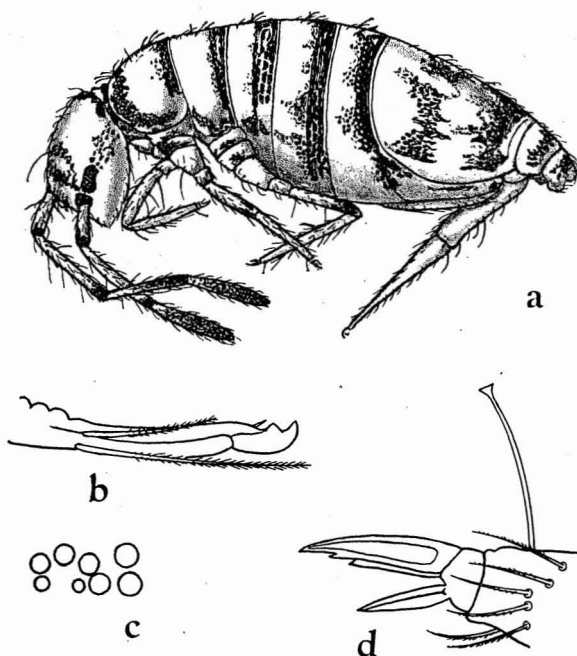


Figure 26—*Entomobrya multifasciata imminuta* Folsom: a, lateral aspect; b, left mucro and end of dens; c, eyes of left side; d, left hind foot.

Genus **LEPIDOCYRTUS** Bourlet, 1839

## KEY TO THE SPECIES FOUND IN HAWAII

1. Mesonotum extending over base of head; apical tooth of mucro long and slender; white species..... **heterophthalmus** Carpenter.  
Mesonotum not projecting over base of head; apical tooth of mucro short..... 2
- 2(1). Iridescent purple or metallic gray..... **cyaneus** Tullberg.  
White or pale yellowish species..... 3
- 3(2). Body entirely white; fourth abdominal segment three to four times as long as third..... **immaculatus** Folsom.  
Derm white or pale yellow, most individuals faintly flecked with blue; fourth abdominal segment less than twice as long as third..... **inornatus** Folsom.

**Lepidocyrtus cyaneus** Tullberg (fig. 27, a-d).

*Lepidocyrtus cyaneus* Tullberg, 1871:150. Folsom, 1932:68, pl. 8, figs. 89-91.

Oahu.

Immigrant. Cosmopolitan. First recorded from Hawaii by Folsom (1932:68).

In soil of pineapple fields.

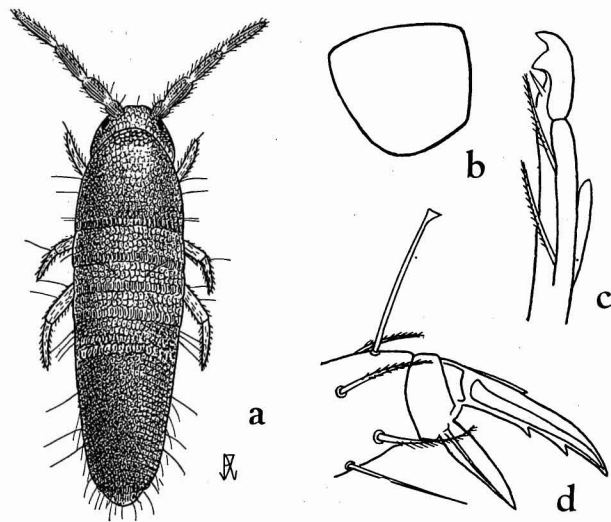


Figure 27—*Lepidocyrtus cyaneus* Tullberg: a, dorsal aspect; b, left aspect of mesonotum; c, left mucro and end of dens; d, right hind foot. (a, after Williams, 1931.)

**Lepidocyrtus heterophthalmus** Carpenter.

*Lepidocyrtus heterophthalmus* Carpenter, 1904:300, pl. 9, figs. 1-6.

Hawaii (type series from Kona, 2,000 feet, and Mauna Loa, 4,000 feet).

Immigrant(?).

**Lepidocyrtus immaculatus** Folsom (fig. 28, c-e).

*Lepidocyrtus immaculatus* Folsom, 1932:68, pl. 9, figs. 94-96.

Oahu, Maui (type locality).

Immigrant.

In soil of sugarcane and pineapple fields.

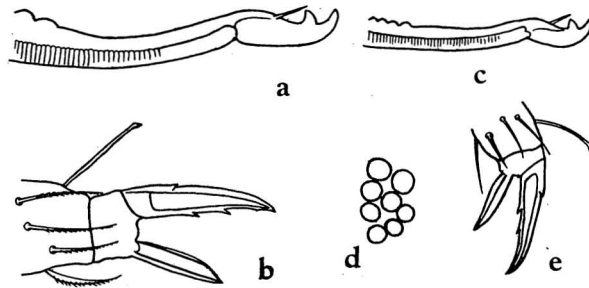


Figure 28—**a-b**, *Lepidocyrtus inornatus* Folsom: **a**, left mucro and end of dens; **b**, left hind foot. **c-e**, *Lepidocyrtus immaculatus* Folsom: **c**, right mucro and end of dens; **d**, eyes of right side; **e**, right hind foot.

**Lepidocyrtus inornatus** Folsom (fig. 28, a-b).

*Lepidocyrtus inornatus* Folsom, 1932:68, pl. 9, figs. 92-93.

Oahu (type locality: Honolulu).

Immigrant.

In soil of pineapple fields.

Genus **DREPANOCYRTUS** Handschin, 1925**Drepanocyrtus terrestris** Folsom (fig. 29, a-i).

*Drepanocyrtus terrestris* Folsom, 1932:69, pl. 9, figs. 97-102; pl. 10, figs. 103-104.

Oahu (type locality).

Immigrant.

This is an abundant species, and may be the one reported to build up such large populations in pineapple fields. Common in soil of pineapple and sugarcane fields, under mulching paper, under sugarcane leaf sheaths; it is said to feed on decaying vegetable debris.

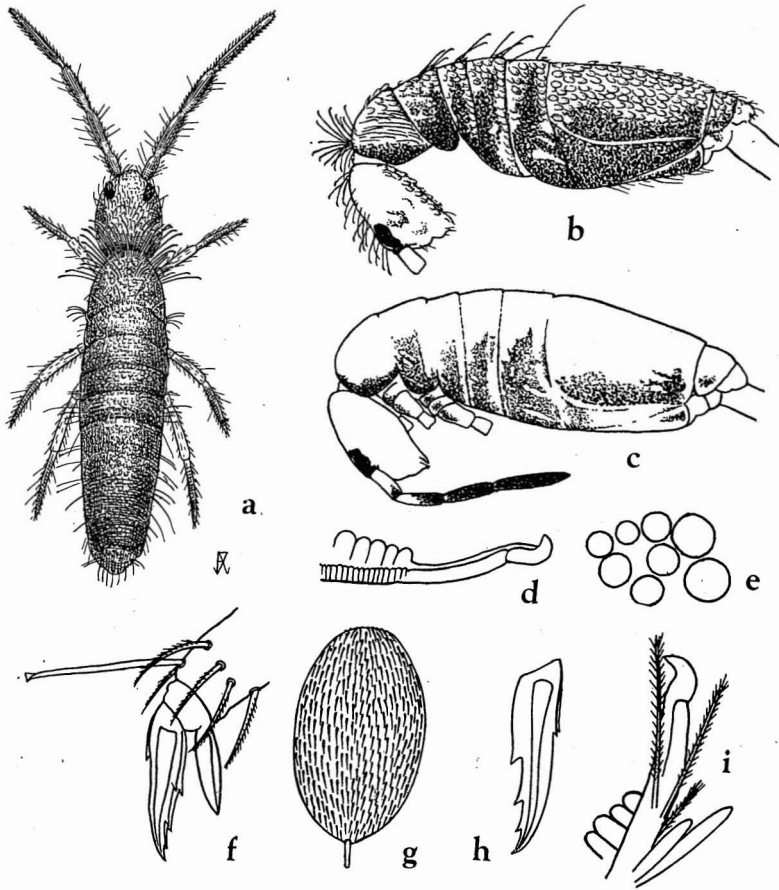


Figure 29—*Drepanocyrtus terrestris* Folsom: a, dorsal aspect (after Williams); b-c, lateral aspects with and without vestiture; d, mucro and end of dens; e, eyes of right side; f, left hind foot; g, a typical body scale; h, unguis; i, left mucro and end of dens.

Subfamily PARONELLINAE  
 Tribe PARONELLINI Börner, 1906  
 Genus **SALINA** MacGillivray, 1894

*Cremastocephalus* Schött, 1896:175.

*Salina maculata* Folsom (fig. 30, a-f).

*Salina maculata* Folsom, 1932:71, pl. 10, figs. 105-110.

Kauai, Oahu, Hawaii (no more definite type locality given).

Immigrant.

In soil of sugarcane fields; under leaf sheaths of sugarcane; on coffee leaves.

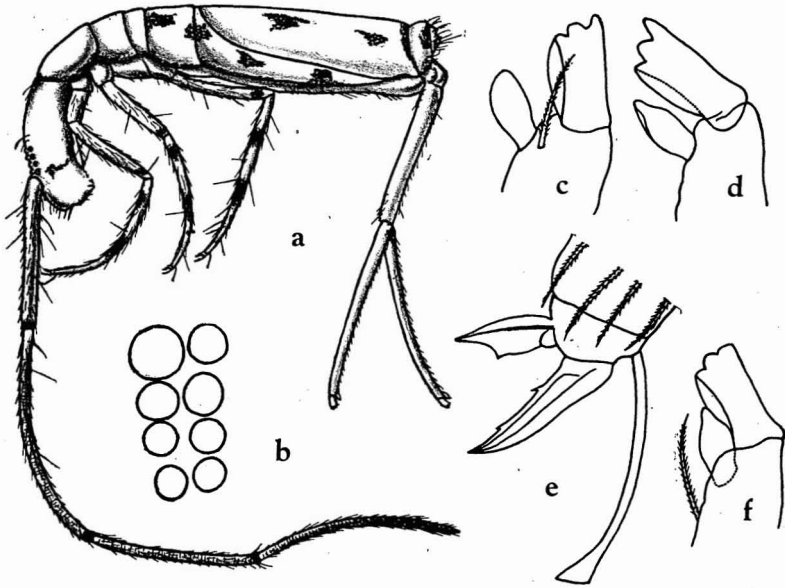


Figure 30—*Salina maculata* Folsom: a, lateral aspect; b, eyes of right side; c, f, right mucro; d, left mucro; e, left middle foot.

Subfamily CYPHODERINAE  
 Tribe CYPHODERINI Börner, 1906  
 Genus **CYPHODERUS** Nicolet, 1841

**Cyphoderus assimilis** Börner (fig. 31, a-b).

*Cyphoderus assimilis* Börner, 1906:181. Folsom, 1932:71, pl. 10, figs. 111–112.

*Cyphoderus similis* Folsom, 1927:12, pl. 8, figs. 70, 71.

Oahu.

Immigrant. West Indies, Panama (type locality), Java. First recorded from Hawaii by Folsom (1932:71).

Members of this genus are usually myrmecophilous or termitophilous. This species has been found with *Pheidole megacephala* ants in Hawaii.

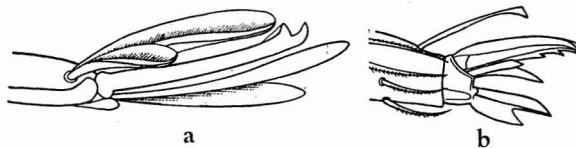


Figure 31—*Cyphoderus assimilis* Börner: a, left mucro; b, left hind foot.

## Suborder SYMPHYPLEONA Börner, 1901

## Family SMINTHURIDAE Lubbock, 1870

## KEY TO THE SUBFAMILIES

1. Exsertile vesicles of ventral tube with smooth walls; segmentation of thorax evident dorsally.....**Sminthuridinae.**  
Exsertile vesicles of ventral tube with tuberculate walls; segmentation of thorax obsolete..... 2
2. Antennae bent between segments three and four, segment four longer than three; furcula-bearing somite without dorsal papillae .....**Sminthurinae.**  
Antennae bent between segments two and three; segment three longer than four; furcula-bearing somite with dorsal papillae .....**Dicyrtominae.**

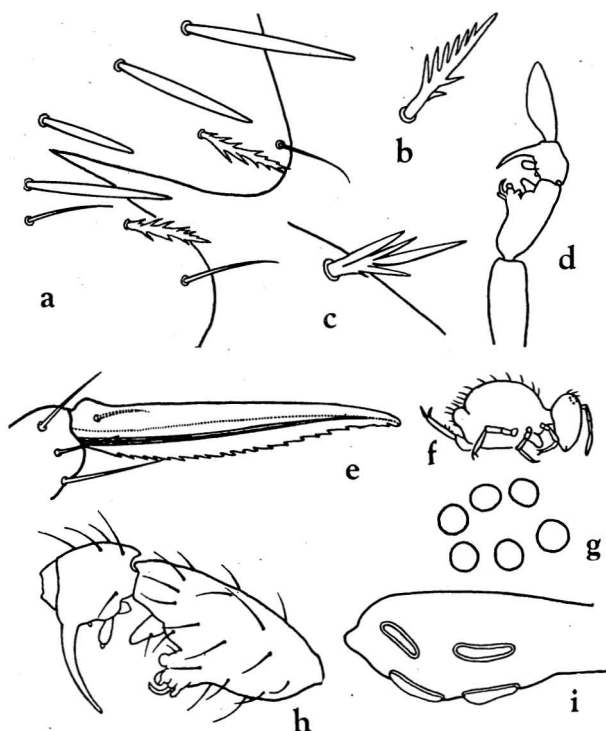


Figure 32—*Sminthurides* (*Denisiella*) *ramosus* (Folsom): a, left aspect of suranal and left subanal lobes of female; b-c, branched setae of left subanal lobe of female; d, left antenna of male; e, left mucro of male; f, lateral aspect; g, eyes of left side; h, second and third antennal segments of male; i, base of fore tibiotarsus of male.

Subfamily SMINTHURIDINAE Börner, 1906

Tribe SMINTHURIDINI Börner, 1913

Genus **SMINTHURIDES** Börner, 1900

*Prosminthurus* Willem, 1900.

See Folsom and Mills (1938:231-274, 9 pls.) for a revision of the genus with noteworthy discussion.

Subgenus **Denisiella** Folsom and Mills, 1938:264

**Sminthurides (Denisiella) ramosus** (Folsom) (figs. 32, a-i; 33, a-f).

*Sminthurides ramosus* Folsom, 1932:72, pl. 10, fig. 113; pl. 11, figs. 114-123; pl. 12, figs. 124-126.

*Sminthurides (Denisiella) ramosus* (Folsom) Folsom and Mills, 1938:266, pl. 8, figs. 94-101, emended description.

Oahu (type locality: Honolulu).

Immigrant. Folsom and Mills (1938:267) say that the closest known relative of this species is *sexpinnatus* Denis of Costa Rica.

In soil of sugarcane fields.

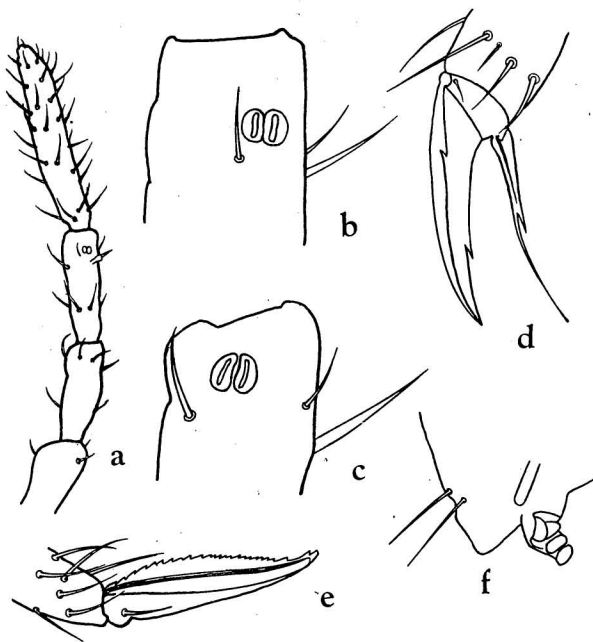


Figure 33—*Sminthurides (Denisiella) ramosus* (Folsom): a, left antenna of female; b-c, sense organ of third antennal segment of left side of female; d, right fore foot of male; e, left mucro of female; f, left aspect of tenaculum of female.



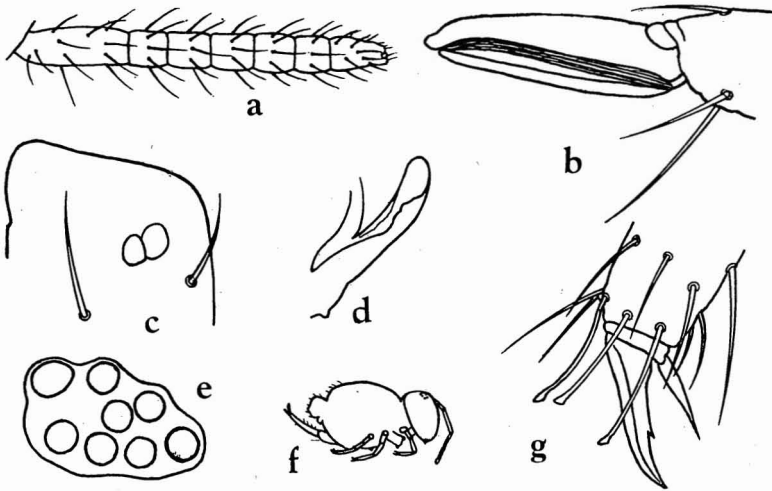


Figure 34—*Bourletiella insula* Folsom: a, fourth antennal segment of female; b, left mucro; c, sense organ of third antennal segment, left side; d, lateral aspect of left subanal appendage of female; e, eyes of left side; f, sketch of lateral aspect; g, left fore foot.

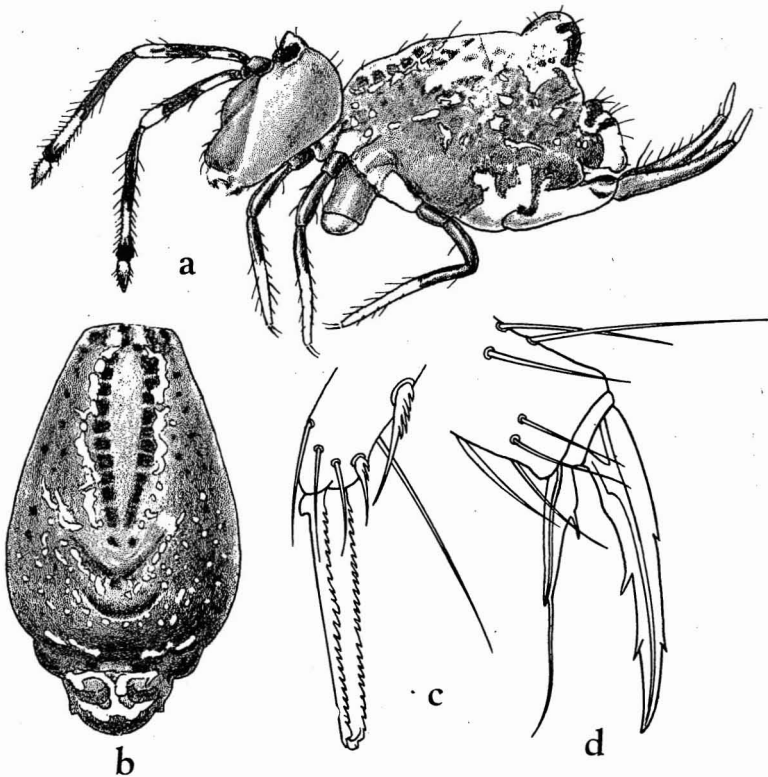


Figure 35—*Ptenothrix dubia* Folsom: a, lateral aspect; b, dorsal aspect of body; c, left mucro; d, left hind foot.

Subfamily SMINTHURINAE Börner, 1906

Tribe BOURLETIELLINI Börner, 1913

Genus **BOURLETIELLA** Banks, 1906

**Bourletiella insula** Folsom (fig. 34, a-g).

*Bourletiella insula* Folsom, 1932:73, pl. 12, figs. 127-132.

Oahu (type locality: Honolulu).

Immigrant.

In soil of sugarcane fields.

Subfamily DICYRTOMINAE Börner, 1906

Genus **PTENOTHRIX** Börner, 1906

**Ptenothrix dubia** Folsom (fig. 35, a-d).

*Ptenothrix dubia* Folsom, 1932:74, pl. 12, figs. 133-136.

Oahu (type locality: Mount Tantalus).

Immigrant.

On damp rocks along streams.

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## Subclass **PTERYGOTA** (Brauer) Lang, 1889

(*pterygotos*, winged)

*Pterygonea* Brauer, 1885.

The insects of this subclass normally go through a metamorphosis of slight or great degree; they are primarily provided with wings, although most orders have secondarily wingless adults within their ranks; they lack the additional abdominal appendages found in the Apterygota.

## Division I. **EXOPTERYGOTA** Sharp, 1898

(*exo*, outside; *pterygotos*, winged)

*Hemimetabola* Burmeister, 1829.

*Heterometabola* Packard, 1888, in part.

This subdivision contains those pterygotan insects which pass through a comparatively simple metamorphosis (wanting in some forms) which is usually without the interpolation of a pupal instar; as a general rule the wings develop externally on the bodies of the nymphs; the young animals are generalized nymphs instead of specialized larvae, and most of them more or less resemble the adults, with the exception that the wings and sexual organs are not developed.

## Order **ORTHOPTERA** Olivier, 1789

(*orthos*, straight; *pteron*, wing)

Cockroaches, Grasshoppers, Locusts, Mantids, Katydid, Leaf Insects,  
Stick Insects, Crickets

Of the seven families of Orthoptera accepted by more conservative workers, five have representatives in Hawaii. The two families not found in our fauna are the Phasmidae (stick and leaf insects, widespread and common in the tropics especially) and the Grylloblattidae (a group of a few peculiar, cricket-like insects found under stones in certain restricted snowy mountain regions of western North America and in Japan). Of the five families found in Hawaii, only the Tettigoniidae and Gryllidae are represented in the native fauna. All of the members of the other three families are extrinsic.

Compound eyes and ocelli present in most species; antennae moniliform or filiform, greatly elongated in some families; mouth parts generalized, exposed,

masticatory, mandibles strongly developed, with two articulations with the head; wings variable, secondarily absent, incompletely developed, fore wings only present or all strongly developed; venation generalized, complex, supernumerary veins and primitive vein network (*archedictyon*) common; fore wings (*tegmina*) usually narrower than hind pair, thickened, leathery and modified to give protection to hind pair; hind wings membranous, folded fan-like longitudinally, also folded transversely in some forms when at rest, vannal area strongly developed; abdomen usually with 10 evident segments, the remainder modified or wanting, cerci present in our species, segmented or not; ovipositor reduced and concealed in Blattidae and Mantidae, exserted and distinct in Acrididae, Tettigoniidae and Gryllidae (except *Gryllotalpa*); legs saltatorial, cursorial, raptorial or fossorial; tarsal segments variable, from none to five; stridulation characteristic among Saltatoria, and tympanal organs present in the stridulating groups; ovoviviparous or oviparous, some species parthenogenetic; eggs laid singly or in groups, inserted in plant tissue or in soil, enclosed within a characteristic capsule (*ootheca*) in Blattidae and Mantidae; some species fitted with repugnatorial glands; phytophagous, predaceous or omnivorous.

This order has the most ancient lineage of contemporary insects, and its fossil record is considered the most completely known. Cockroaches, for example, were much more common far back in the Upper Carboniferous, when they apparently reached their zenith of development and diversity, than they are today. It does not follow, however, that all orthopterans are ancient insects, for some groups (our modern Acridinae, for example) are not represented as fossils until Pleistocene times.

Orthoptera are pre-eminently a tropical group, although many species are found in temperate zones. The greatest diversity of forms is found in the tropics of the Eastern Hemisphere. More than 20,000 species have been described.

This order contains no minute insects, and, comparatively speaking, the average orthopteran is a rather large insect. Perhaps the most bulky of living insects belong here, and certainly some of the Phasmidae are the longest of contemporary insects, for some exceed 10 inches in length. Some of the most bizarre and remarkable organisms of the Animal Kingdom are found in the order.

Orthoptera have attracted many students, and a great body of data is amassed about many phases of the group, from fossil history and embryology to musical ability and psychology. The group has retained some generalized or primitive types of structure and has been much used in laboratories for purposes of instruction and experimentation. Contrary to popular belief, however, the animals are not entirely "primitive" in structure because many parts of their bodies are highly evolved or specialized.

The economic importance of the order hardly needs emphasis. The great plagues of locusts, the devastation wrought and influence on man are commonplace in ancient and modern history of many lands. Even today with all our highly developed methods for combating such hordes, millions of dollars worth of damage is done every year on all of the continents because of the ravages of Orthoptera

upon man's crops. Corps of technicians are employed constantly in studying the detrimental species, and each year thousands of square miles of land are strewn with poisons in attempts to control the pests. Fortunately for us in Hawaii, comparatively little damage is done by Orthoptera, but several of the species found here are pests; some cause material damage, and the mere presence of others constitutes a general nuisance. The importation of additional, more harmful species is an ever-present possibility.

Many kinds of parasites are known to attack various Orthoptera, and they are discussed under each family. Parasites other than those already attacking various species in Hawaii are known elsewhere, and these should be investigated with the purpose of introduction in mind.

The bulk of our species are nocturnal, and the layman seldom comes in contact with more than a few of our more than 80 species. Members of the group are to be found throughout Hawaii from seashore to mountain top. Without exception, the lowland species are immigrants, but our forests have a most interesting fauna of native species, some of which belong to unusual endemic genera.

I have not given detailed or complete synonymy here, but such data are available in the literature cited in the bibliography, especially in the works of Kirby (1904, 1906, 1910) and Hebard (1922, 1933).

TABULAR ANALYSIS OF THE HAWAIIAN ORTHOPTERA

FAMILY	GENERA	ENDEMIC GENERA	NON- ENDEMIC GENERA	SPECIES	ENDEMIC SPECIES	ADVENTIVE SPECIES
Blattidae	15	0	15	18	0	18
Mantidae	3	0	3	3	0	3
Acrididae	3	0	3	3	0	3
Tettigoniidae	6	2	4	16	12	4
Gryllidae	11	3	8	42	33	9
Totals	38	5	33	82	45	37

Percentage of endemism in native group: genera, 100 percent; species, 100 percent.

Percentage of present-day fauna native: 54 percent.

Percentage of present-day fauna adventive: 45 percent.

Average number of species per genus in native group: 9.

Average number of species per genus in adventive group: 1.2.

#### KEY TO THE FAMILIES OF ORTHOPTERA FOUND IN HAWAII

1. Tarsi five-segmented; hind legs not much larger than others, not developed for leaping; head deflexed and more or less concealed beneath pronotum or entirely exposed and then with fore legs raptorial..... 2
- Tarsi with four segments or less; hind legs either strongly developed for leaping and larger than others or not developed for leaping and with three-segmented tarsi and with fore tibiae and tarsi remarkably modified for burrowing (*Gryllotalpa*), and otherwise not as above; Suborder Saltatoria ..... 3



- 2(1). Head deflexed and concealed beneath shield-like pronotum;  
 Suborder Cursoria ..... (cockroaches) **Blattidae**.  
 Head not at all concealed, broader than the elongate, neck-  
 like prothorax, fore legs raptorial (fitted with strong spines  
 and modified for grasping prey); Suborder Gressoria  
 ..... (mantids) **Mantidae**.
- 3(1). Antennae not longer than one-half the body (but fore legs  
 never fossorial); ovipositor short and comparatively incon-  
 spicuous, never blade-like; tarsi three-segmented; tympana  
 located on sides of first abdominal segment.....  
 ..... (short-horned grasshoppers) **Acrididae**.  
 Antennae usually as long as, or much longer than, body (less  
 than one-half as long as body in *Gryllotalpa* only); tarsi  
 three- or four-segmented; ovipositor usually, not always,  
 long and blade-like, sickle-shaped or cylindrical (concealed  
 only in *Gryllotalpa* and slender and sometimes compara-  
 tively obscure in *Myrmecophila*); tympana situated on fore  
 tibiae (wanting in *Myrmecophila*)..... 4
- 4(3). Tarsi four-segmented .....  
 ..... (longhorned grasshoppers, katydids) **Tettigoniidae**.  
 Tarsi three-segmented..... (crickets) **Gryllidae**.

### Suborder CURSORIA (Latreille, 1817)

#### Family BLATTIDAE (Burmeister, 1840)

*Blattariae* Latreille, 1810.

*Blattaria* Burmeister, 1829.

*Cursoria* Westwood, 1839.

*Blattoidea* Brunner, 1882.

*Oothecaria* Escherich, 1914.

Cockroaches, Roaches; Hawaiian name: "elehu"

Swift-running animals of depressed form, usually ovate; head concealed or almost concealed beneath pronotum, directed ventro-caudad so that the face is almost horizontal when at rest; antennae inserted below eyes, long and filiform, segments short, multitudinous; compound eyes usually large, reniform; ocelli or ocellar spots (*fenestrae*) present; mandibles large, dentate; maxillary palpi five-segmented; labial palpi three-segmented; pronotum large, shield-like; tegmina and hind wings variable, present or absent, subject to sexual dimorphism, abbreviated or longer than abdomen, tegmina held flat over pterothorax and abdomen and overlapping when at rest; abdomen 10-segmented, usually only seven or eight tergites visible, females with seven visible ventrites, males with nine; tenth tergite called the *supra-anal plate* and bearing the segmented cerci; seventh or ninth ventrite called the *subgenital plate* and bearing a pair of unsegmented *styles* in the males; ovipositor wanting; legs with coxae large, broad, depressed, plate-like, femora compressed, tibiae strongly spinose, tarsi five-segmented, fifth segment

with or without arolia between the widely separated, paired claws, first four segments usually with pulvillae; oviparous or ovoviviparous, some forms producing characteristic *oothecae* (egg cases).

The cockroaches hardly need a detailed introduction, for they and their nocturnal activities are well known to the average resident of Hawaii. There are 18 species included in 15 genera found here; all of them are immigrants. The number of cockroaches described from the world is probably near 1,500 species, and they are predominantly insects of the tropics. However, temperate zones are not entirely without endemic representatives of the family, and several cosmopolitan species are regular residents of temperate countries.

Dr. J. A. G. Rehn has said (1945:265):

The cockroaches are insects which to the average person are house-haunting pests, living secretive lives away from the light of day, and creeping into one's larder when given the slightest opportunity. Most definitely they produce in the majority of people a strong feeling of aversion. It often takes some effort to convince the "doubting Thomases" that the number of species of cockroaches which are domiciliary pests is greatly limited—in fact less than one percent of the known forms—and that cockroaches of many kinds are diurnal, with hundreds of species tropical forest foliage forms, others semiaquatic, some in one sex living in the ground, a few wood-boring, while a dozen or so genera will be found, in a state of either known or suspected commensalism, in the nests of ants, wasps, or termites.

This paper by Dr. Rehn should be consulted also for an interesting account of the original homes and the dispersal of the "domestic" roaches.

Fossil cockroaches are abundant in many horizons; in fact, over 90 percent of the insects of some Upper Carboniferous deposits are said to be cockroaches. However, their dominant position has been lost with the ages, for they now compose only a fraction of 1 percent of present-day insects. Their fossil record is the most complete of the Insecta, and they are, as a group, considered among the oldest of winged insects.

Cockroaches have well-developed powers of organ regeneration, and may regenerate legs, antennae and cerci if these organs are broken. Some species are known to have prelocalized points of weakness in their legs and antennae, at which places it is usual for the appendages to break if damaged. A worthwhile paper on regeneration is that by Woodruff (1937), which includes a good bibliography.

One of the most interesting features of the Blattidae is the peculiar egg cases produced by most species. These oothecae are formed by the female over a period of several days as her eggs mature. They consist of a purse-like or seed-like structure composed of a hardened material secreted by accessory genital glands. Each is divided lengthwise into two compartments in which the eggs are set upon end, a longitudinal row in each compartment. When the batch of eggs has been completely enclosed, the female roach attaches it in some protected place, or it is dropped loosely. Female roaches often are seen with partially formed oothecae protruding from their abdomens. The size, shape, design and number of eggs included vary with the species, and many of the oothecae are diagnostic and enable one to name easily the species of roach depositing the egg case. The young hatch-

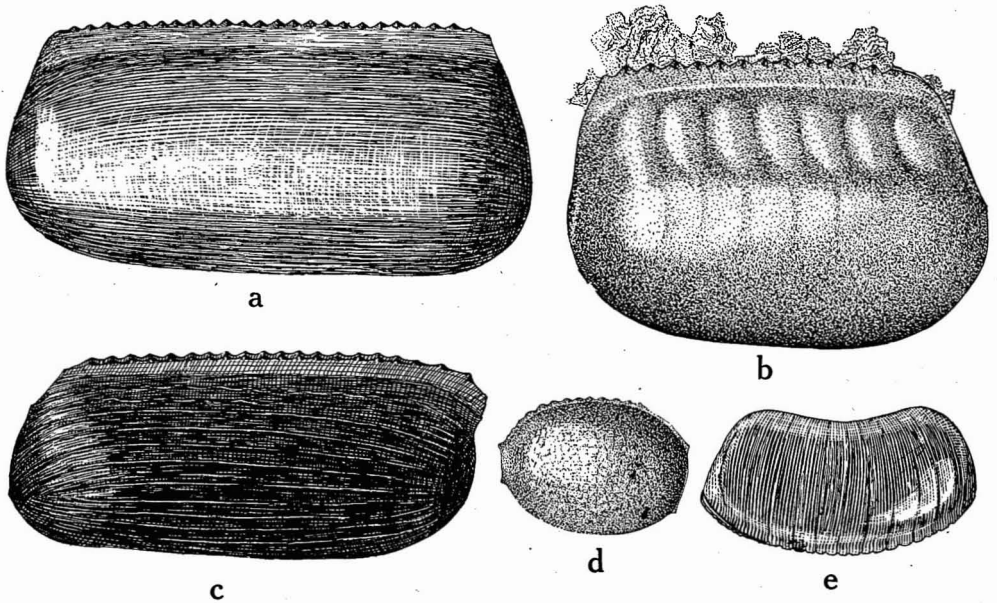


Figure 36—Some cockroach egg cases (oothecae): a, *Periplaneta australasiae* (Fabricius); b, *Periplaneta americana* (Linnaeus); c, *Cutilia soror* (Brunner); d, *Euthyrrhapha pacifica* (Coquebert); e, *Symploce hospes* (Perkins). (Drawings by Williams, 1931.)

ing from the oothecae produce the characteristic batches of individuals of similar size that we see so often in our homes.

Most cockroaches are omnivorous feeders, and the so-called "domestic" species feed upon almost any edible thing they can find—even their fellows when opportunity permits—including all sorts of food stuffs, book bindings, paper, wall paper, starched clothing, woolens, glued and pasted articles, labels, living and dead insects (often seriously damaging unprotected museum specimens), dead organic matter, leather, sweets, starchy or farinaceous materials; some feed upon the roots, bark, foliage, flowers, and fruits of various plants out-of-doors. Some "domestic" species eat flowers of various plants when they are established in unsettled places such as uninhabited islands. I have even had them gnaw on my feet while sleeping on a copra schooner traveling in Fijian waters. The damage they do to paper and book bindings is easily confused with that of silverfish. Their feces soil every place they frequent, and their presence in closets and kitchen cupboards is thus easily ascertained even though the cockroaches may be hidden away in cracks and crannies. Some species throw off a disagreeable musk and at times may thus spoil food and give a most unwholesome and persistent odor to anything with which they come in contact; drawers and cupboards frequented by them become fouled and obnoxiously odoriferous.

Cockroaches have many enemies, both parasitic and predaceous. In Hawaii there are two species of *Evania* wasps which parasitize the oothecae of several kinds of cockroaches, as do the small wasps, *Solindenia picticornis* Cameron and *Comperia*

*falsicornis* (Gomes). Dr. Williams recently introduced the brilliantly colored "jewel wasp," *Ampulex compressa* (Fabricius), from New Caledonia as an additional parasite for our larger cockroaches (for a detailed and most readable, well-illustrated account of this species see Williams, 1942:221). *Dolichurus stantoni* Ashmead, a small Philippine wasp, is also an introduced parasite. The eulophid hypoparasite *Tetrastichus hagenowii* Ratzeburg attacks the *Evania* parasites in the oothecae and may be erroneously thought to be a parasite of the cockroach eggs when observed emerging from them. The introduced toad, *Bufo marinus*, eats quantities of cockroaches as do geckoes, skinks and mongooses, and sparrows and mynah birds catch a share. Chickens and other barnyard fowl eat quantities of these insects when they can get them, but, unfortunately, one of the roaches most likely to be eaten is an intermediate host for Manson's eye worm. Our larger spiders are effective cockroach hunters, and the large, harmless but tarantula-like *Heteropoda regia* (Fabricius) frequently found in buildings is especially adept in catching roaches and should be harbored rather than killed, as often is done in many households.

Few insects have had more methods suggested for their control, some of them good, many ineffective. As with silverfish, one of the most effective methods of clearing a building of the pests is cyanide fumigation, but it is not always possible to use this deadly gas, and other methods of control must be resorted to. It should be borne in mind, however, that although a room or a building may be cleared of roaches by fumigation, it may become rapidly reinfested by the influx of specimens from the outside. A standard DDT 5 percent spray or 10 percent dust is coming into common use and is a simple and very effective method of control. DDT is replacing rapidly the older methods of control which are listed hereafter. It should be sprayed or dusted in places where the cockroaches will run over it. Powdered pyrethrum or sodium fluoride, or a combination dust including both poisons, dusted about places frequented by the pests is an easy and efficient method to aid in their control, and was, perhaps, the method most usually recommended before DDT came into use recently. In place of pyrethrum or sodium fluoride, powdered borax, which is a common ingredient in commercial roach powders, may be used. It may also be mixed with ground chocolate at the rate of one part borax to three parts chocolate and used as a poisoned bait. Some people in Hawaii report excellent control by the use of a bait consisting of one tablespoon of sugar mixed with one cup of borax. A trap similar to that used for silverfish, but baited with molasses, rancid butter, wine, beer or other alcoholic beverage, or most any readily eaten food as bait may be used. Such traps may be used safely near food or where children or pets have access to them. An unusual method of control recommended by some workers is to mix one part of plaster of Paris with three or four parts of flour. This mixture is placed in a plate, and close by is placed a shallow plate of water containing paper or similar article to enable the roaches to drink readily. The roaches will eat the plaster and flour mixture, become thirsty, drink the water which sets the plaster and thus clog the digestive tract causing death. A poison paste made from 1 or 2 percent phosphorus in sweetened flour is said to be effec-

tive and, certainly, if eaten would be a deadly poison. Arsenical baits are not effective. A number of baits, dusts and sprays are available from many commercial dealers. A spray of some such material as "Flit" is temporarily effective for use in cabinets, closets and cupboards. Naphthalene (flakes or moth balls) and paradichlorobenzene crystals are effective in keeping cockroaches out of closed containers, drawers, closets, etc., and will kill the insects if in sufficient concentration. Stored materials (other than foodstuffs) susceptible to attack should always be protected with an ample supply of some such fumigant and then sealed. To protect book bindings and similar articles, the liquid poison outlined in a previous chapter for the control of silverfish is recommended.

No matter how clean and careful the inhabitants, cockroaches will gain entrance to most homes in Hawaii. The pests are masters at the art of entering buildings in the most devious of ways. To combat the roaches successfully, kitchens, pantries and dining areas should be kept spotlessly clean, no food should be exposed overnight, all cracks around windows and outside doors (especially at the floor edges of the doors, which are common points of entry) that are large enough for roaches to enter should be made tighter and proper garbage disposal is essential for effective control. Of course, all oothecae found should be immediately destroyed, and they should be searched for in closets, above and behind drawers, on the undersides of chairs and tables, and in similar obscure places. Even with these precautions and the use of poisons and traps, cockroaches will gain entrance, but their numbers will be small. If one darkens the kitchen for an hour or so at night, then enters and turns on the light, he may kill many roaches with a fly swatter. This method, although elementary, is quite effective in keeping the populations at a minimum and is to be recommended. I have found a solution of DDT (which has come into use since this text was written) painted on the lower edges of outside doors and thresholds, along base boards, and along the inside corners of cupboards an excellent agent in control.

Decoctions of cockroaches are used medicinally in various places, and even yet are listed in some pharmacopoeia.

The name cockroach is said to be a corruption of the Spanish "cucuracha."

Because cockroaches are such common insects, I feel that a simplified key to the 18 species now known to occur in the islands will be more useful than one based upon characters used to differentiate the subfamilies, some of which are not easily seen nor understood by workers unfamiliar with the group.

#### SIMPLIFIED KEY TO THE COCKROACHES FOUND IN HAWAII

##### (Adults)

1. Tegmina developed, either brachypterous or fully formed,  
but always concealing pterothorax at least..... 2
- Tegmina reduced to small pads which do not completely  
conceal the meso- or metathorax, excepting *Loboptera*  
*dimidiatipes*, on which the mesonotum is concealed and  
the metanotum is exposed only at middle behind.....15

- 2(1). Small to medium-sized species, less than 20 or 22 mm. in length ..... 3  
 Large to very large species, over 22 mm. long, usually longer than 25 mm. .... 11
- 3(2). Thorax and tegmina rather dull, densely punctate or roughened, conspicuously hairy; tegmina leathery, densely opaque, veins not well-marked ..... 4  
 Thorax and tegmina shiny, not hirsute; tegmina translucent or partly transparent, veins conspicuous ..... 6
- 4(3). Broad species, up to more than 15 mm. in length; hairs on dorsum short ..... **Diploptera dytiscoides** (Serville).  
 Small species, less than 10 mm. long; hairs on dorsum long; anterior and lateral pronotal margins with many long erect setae ..... 5
- 5(4). Each postero-lateral corner of pronotum with a conspicuous, well-defined, yellow spot; a conspicuous, sharply marked, round, yellow spot just behind middle of tegmina; pronotum and tegmina otherwise black ..... **Euthyrrhapha pacifica** (Coquebert).  
 Without such well-defined spots; pronotum and tegmina brown; a tiny species about 5 mm. long ..... **Holocompsa fulva** (Burmeister).
- 6(3). Pronotum either almost entirely dark-colored (nearly or quite black), or with two dark vittae, as in figures 40, 49... 7  
 Pronotum not so colored ..... 8
- 7(6). Nearly 20 mm. long; pronotum entirely dark excepting for pale lateral and anterior margins; tegmina with a dark vitta at shoulder ..... **Pycnoscelus surinamensis** (Linnaeus).  
 Usually less than 15 mm. long; pronotum with a pair of characteristic dark vittae, otherwise pale ..... 7a
- 7a(7). Male terminalia as in figure 39. **Blattella germanica** (Linnaeus).  
 Male terminalia as in figure 39. **Blattella lituricollis** (Walker).
- 8(6). Hind margin of pronotum strongly convex, its middle part obviously produced backward so that each side of hind margin extends obliquely forward from middle to sides ..... **Symploce hospes** (Perkins).  
 Hind margin of pronotum subtruncate or feebly convex ..... 9
- 9(8). Tegmina with large numbers of conspicuous cross-veins, veins and cross-veins outstanding and forming a characteristic net-like pattern because of their nearly white coloring; disk of pronotum with narrow, irregular, vermiform, brown markings ..... **Graptoblatta notulata** (Stål).  
 Not as above; cross-veins mostly inconspicuous ..... 10
- 10(9). Species found in dwellings and buildings; with both brachypterous and long-winged forms; wings in long-winged form reaching far behind apex of abdomen to beyond apices of cerci which are thus well-concealed; penultimate segment of maxillary palpi longer than distance between eyes; pronotum not strongly transverse, more strongly narrowed anteriorly, as in figure 42 ..... **Supella supellectilium** (Serville).

- Forest species; no brachypterous forms; wings reaching only slightly behind apex of abdomen and leaving cerci exposed and projecting conspicuously caudad of wing apices; penultimate segment of maxillary palpi obviously shorter than interocular distance; pronotum strongly transverse, nearly twice as broad as long.....  
 .....**Allacta similis** (Saussure). 12
- 11(2). Mahogany or reddish-brown species.....12  
 Yellowish or grayish-brown species.....14
- 12(11). Tegmina with a rather broad, long, yellow, costal vitta at base; pronotum with a complete yellow ring sharply contrasting in color with the dark central part and equally dark margin.....**Periplaneta australasiae** (Fabricius).  
 Humerus of tegmina without a pale vitta and pronotum not so colored, the color pattern less definite.....13
- 13(12). Supra-anal plate with a deep, narrow, acute, median emargination .....**Periplaneta americana** (Linnaeus).  
 Supra-anal plate convex in male, broadly emarginate in female.....**Periplaneta brunnea** Burmeister.
- 14(11). A very large species, usually distinctly more than 40 mm. long; wings extending beyond apex of abdomen, usually far beyond.....**Leucophaea maderae** (Fabricius).  
 Less than 30 mm. long; wings not or hardly reaching apex of abdomen, or at most barely surpassing apex.....  
 .....**Nauphoeta cinerea** Olivier.
- 15(1). Large, robust species, 25 or more mm. long; thoracic nota all irregularly marked with yellow over disks; supra-anal plate with a strong, median, V-shaped notch.....  
 .....**Neostylopyga rhombifolia** (Stoll).  
 Smaller species less than 20 mm. long; thoracic nota with yellow margins only, not marked on disk.....16
- 16(15). Tegmina reduced to small scales at sides of mesonotum; length between 15 and 20 mm.....**Cutilia soror** (Brunner).  
 Tegmina concealing mesonotum and most of metanotum; a small species usually less than 10 mm. long.....  
 .....**Loboptera dimidiatipes** (Bolivar).

#### Subfamily ECTOBINAE

Genus **ALLACTA** Saussure and Zehntner, 1893

**Allacta similis** (Saussure) (fig. 37).

*Blatta similis* Saussure, 1870:245.

*Phyllodromia obtusata* Brunner, 1895:892; described as a Hawaiian species.

*Allacta similis* (Saussure) Hebard, 1922:327.

Kauai, Oahu, Molokai, Maui, Lanai, Hawaii.

Immigrant. Australia. First recorded in Hawaii by Brunner (1895:892). Considered endemic until 1922.





Figure 37—*Allacta similis* (Saussure).

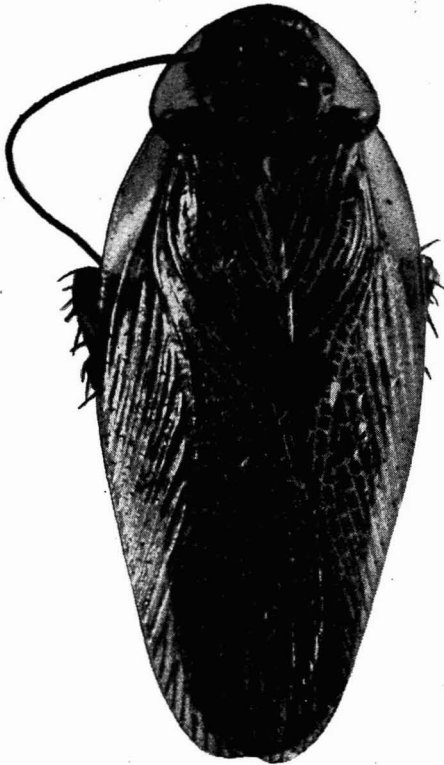


Figure 38—*Graptoblatta notulata* (Stål).



Common under bark, among leaves and clusters of foliage, in hollow stems and on many kinds of plants in forests. Variable and polymorphic.

Parasites: *Solindenia picticornis* Cameron (Hymenoptera: Encyrtidae) in oothecae; *Dolichurus stantoni* Ashmead (Hymenoptera: Ampulicidae) on nymphs.

Predators: some endemic birds (Perkins, 1913:ccxiv).

### Genus **GRAPTOBLATTA** Hebard, 1929

*Eoblatta* Shelford, 1911, not Handlirsch, 1906.

For notes on generic names, see Rehn, 1931:297-304.

#### **Graptoblatta notulata** (Stål) (fig. 38).

*Blatta notulata* Stål, 1860:308; type locality: Tahiti.

*Phyllodromia hieroglyphica* Brunner, 1865:105.

*Eoblatta notulata* (Stål), Hebard, 1922:329, pl. 26, fig. 11. Chopard, 1929:17, fig. 12.

Kauai, Oahu, Molokai, Maui, Lanai, Hawaii, Kure (Ocean).

Immigrant. Widespread in Oceania, Malay Peninsula, Sumatra, Java, Borneo, Celebes, New Guinea, New Caledonia, New Hebrides, Fiji, Samoa, Tahiti, Marquesas, Tuamotus, Easter Island. First recorded from Hawaii by Bormans in 1882.

### Subfamily PSEUDOMOPINAE

#### Genus **BLATTELLA** Caudell, 1903

##### KEY TO THE SPECIES FOUND IN HAWAII

1. Male terminalia as in figure 39; left phallomere slender distad, rather sickle-shaped and not inflated on inner side of distal curvature; virga with edge obliquely grooved distad; supranal plate not over one-half length of cercus, usually shorter ..... **germanica** (Linnaeus).
2. Male terminalia as in figure 39; left phallomere expanded on inner side of apical curvature and the resulting arcuation dentate, the apical filament-like process conspicuously twisted (like a screw); virga without conspicuous grooves; supranal plate about two-thirds as long as a cercus. .... **lituricollis** (Walker).

#### **Blattella germanica** (Linnaeus) (fig. 39).

*Blatta germanica* Linnaeus, 1767:668; type from Denmark.

The German cockroach; croton bug.

Kauai, Oahu, Molokai, Maui, Hawaii, Laysan.

Immigrant. First recorded from the Territory by Perkins (1899:5). Cosmopolitan; an "international" pest; originally a North African species.

This does not seem to be a common species in Hawaii under present, normal

conditions. However, it has been reported occasionally in the past as "swarming" in shops and houses in the islands. During the recent war it became a pest in barracks and kitchens in some newly erected military establishments. It is abundant on many ships docking here. It is not a common cockroach in island homes—*Supella* has that distinction. The field roach, *Blattella lituricollis* (Walker) (which see), rarely enters homes, but it is easily confused with and has been wrongly called *germanica* in our records.

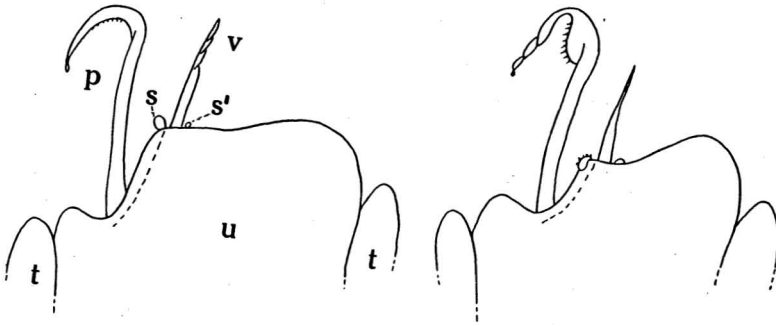


Figure 39.—Terminalia of male *Blattella* as seen from beneath with parts extruded: left, *B. germanica* (Linnaeus); right, *B. lituricollis* (Walker). p, left phallomere; t, edges of ninth tergite; u, subgenital plate (ninth sternite); s, s', left and right styles; v, virga. The phallomere and virga are usually concealed and may have to be dissected out to be seen. (After sketches kindly supplied for this work by A. B. Gurney.)

***Blattella lituricollis* (Walker) (figs. 39, 40).**

*Blatta lituricollis* Walker, 1868:105.

The false German cockroach.

Oahu, Molokai, Hawaii, and probably all the islands, but material at hand inadequate to determine exact range.

Immigrant. An Oriental species known from China, Burma, Philippines, East Indies; (type locality: Amoy). Although present in the islands for many years, it has been confused with *Blattella germanica*.

This is a common, widespread roach of fields in Hawaii. I have found it especially abundant among grasses and weeds along roadways and curbs. It rarely enters dwellings, and, from my experience, it appears that when it is found in a dwelling it is there because it has lost its way, not because of choice. It is frequently attracted to lights. It is very rapid in its movements and is difficult to capture.

The pale oothecae are carried by the female until the young are ready to hatch. I have had the nymphs emerge a few minutes after capturing a female carrying an egg case.

This species is so closely similar to *Blattella germanica* that it was confused with that species in Hawaiian collections until 1946. Dr. Ashley B. Gurney, of the United States National Museum, kindly examined a series of specimens and made

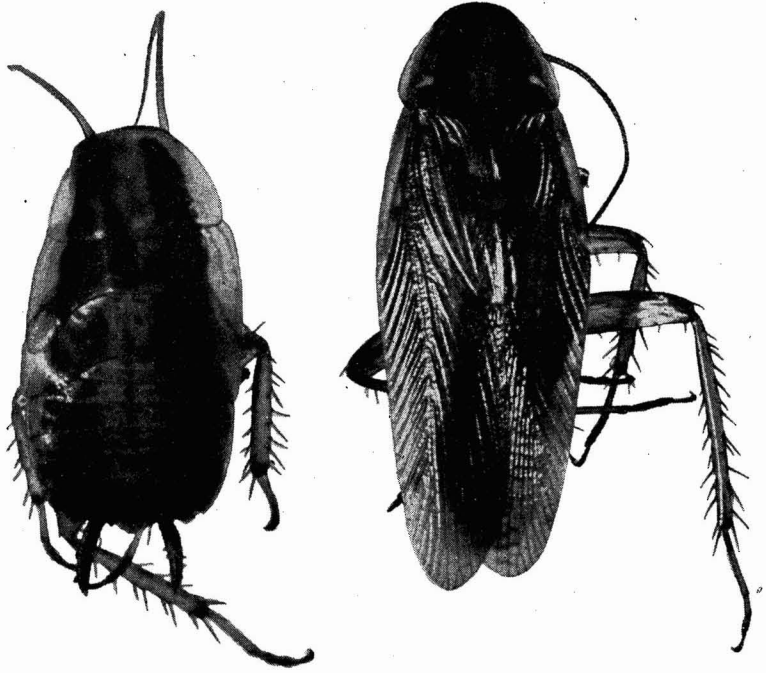


Figure 40—*Blattella lituricollis* (Walker), the false German cockroach, nymph and adult.

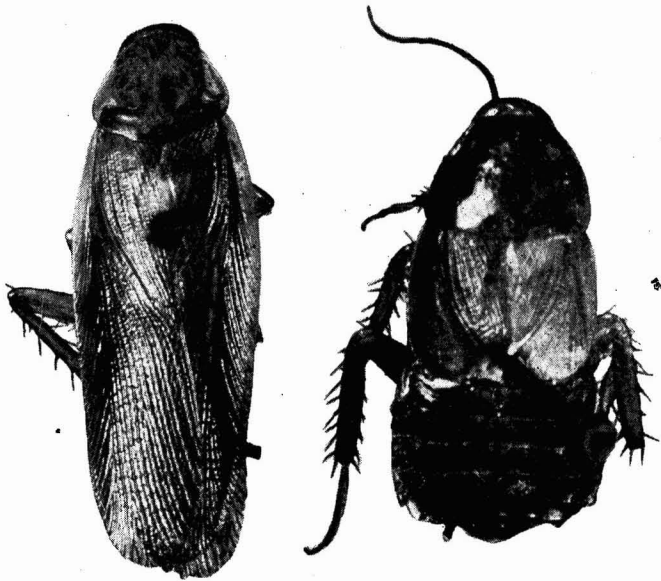


Figure 41—*Symploce hospes* (Perkins). Male, left; female, right.

the identification of this species following his reading of my manuscript notes on the habits of this form in the islands. It is somewhat smaller (10–12 mm. long) and more delicate than *B. germanica*, and the male terminalia are quite distinctive, as the illustrations indicate.

Genus **SYMPLOCE** Hebard, 1916:355

**Symploce hospes** (Perkins) (figs. 36, e; 41).

*Phyllodromia hospes* Perkins, 1899:5; type series from Kauai and Oahu (Honolulu).

*Symploce lita* Hebard, 1916:357, pl. 17, fig. 8; pl. 18, figs. 1–4.

*Symploce hospes* (Perkins) Hebard, 1922:330. Williams, 1931, pl. 2, fig. 4, ootheca.

Kauai, Oahu, and probably the other islands.

Immigrant. Southern United States; Central America. First recorded from Hawaii by Perkins (1899:3).

Common under stones, in rubbish, abundant in grass and weeds.

Female brachypterous; 30 to 40 oothecae produced per year at 3- to 10-day intervals; incubation period about 6 weeks. Bionomical studies by Illingworth (1915:138).

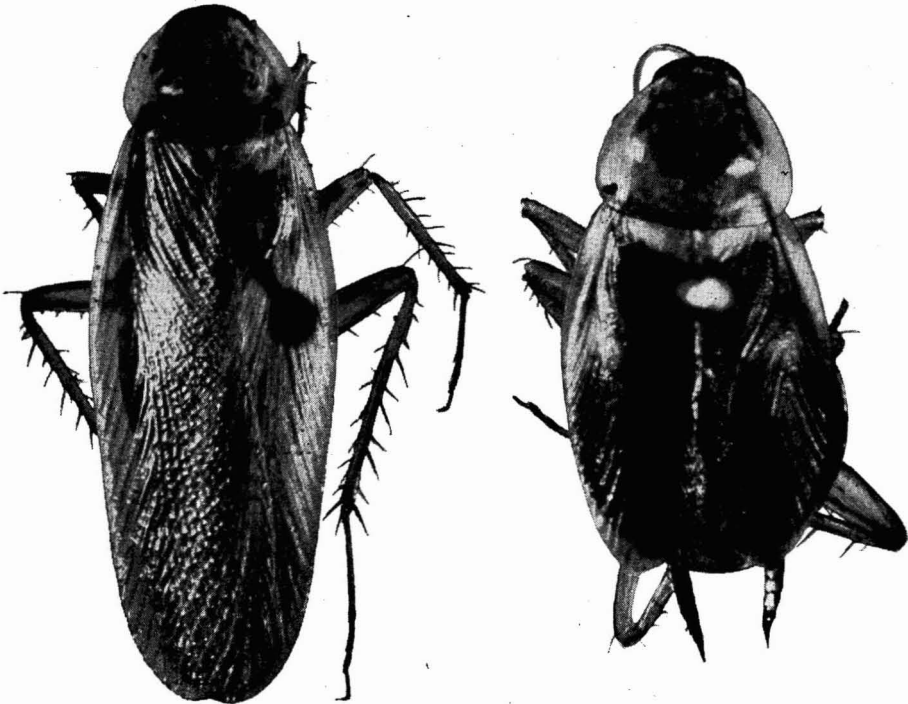


Figure 42—*Supella supellectilium* (Serville), the brown-banded cockroach. Male, left; female, right.

Genus **SUPELLA** Shelford, 1911**Supella supellectilium** (Serville) (fig. 42).*Blatta supellectilium* Serville, 1839:114.

The brown-banded cockroach.

Oahu, Molokai, Maui.

Immigrant. Tropicopolitan; originally an African species. Australia, Fiji, California, Florida, Central and South America. First recorded from Hawaii by Swezey in 1921 from specimens collected at Honolulu.

Parasite: *Comperia falsicornis* (Gomes) (Hymenoptera: Encyrtidae), on the eggs.

This species resembles closely our *Symploce*, but it can be separated easily by the different shape of the pronotum, which in this species is subtruncate behind instead of being produced caudad in the middle as in *Symploce hospes*. The females are brachypterous.

Until recently, this was the commonest cockroach in residences in Honolulu. However, since the accidental importation of the splendid *Comperia* egg parasite, the species has been practically wiped out in some places. For a number of years my own home supported continuously a healthy population of *Symploce*, but since I began work on the parasites, I have had difficulty in finding oothecae for experimental purposes. I have spread the parasite to other parts of Honolulu and have had success in controlling the roach in a store building. As many as 20 parasites were reared from one ootheca, and in some surveys I have found nearly 100 percent parasitism of all oothecae located. My preliminary report on the parasite is in *Proc. Hawaiian Ent. Soc.* 12(1):20, 1944. DDT is an excellent insecticide for use in controlling this species.

Genus **LOBOPTERA** Brunner, 1865**Loboptera dimidiatipes** (Bolivar) (fig. 43).

*Temnopteryx dimidiatipes* Bolivar, 1890:300, pl. 1, fig. 1.

*Temnopteryx sakalava* Saussure, 1891:25. Synonymy by Hebard, 1933:121.

*Loboptera sakalava* (Saussure), of authors.

*Loboptera extranea* Perkins, 1899:6; type series from Maui and Hawaii. Synonymy by Hebard, 1922:331 and 1933:121.

Figured by Williams, 1931:51.

Kauai, Oahu, Maui, Hawaii.

Immigrant. Africa to Philippines, New Caledonia, Fiji, Samoa, Tahiti, Marquesas. First recorded from Hawaii by Perkins (1899:6).

This is a brachypterous species.

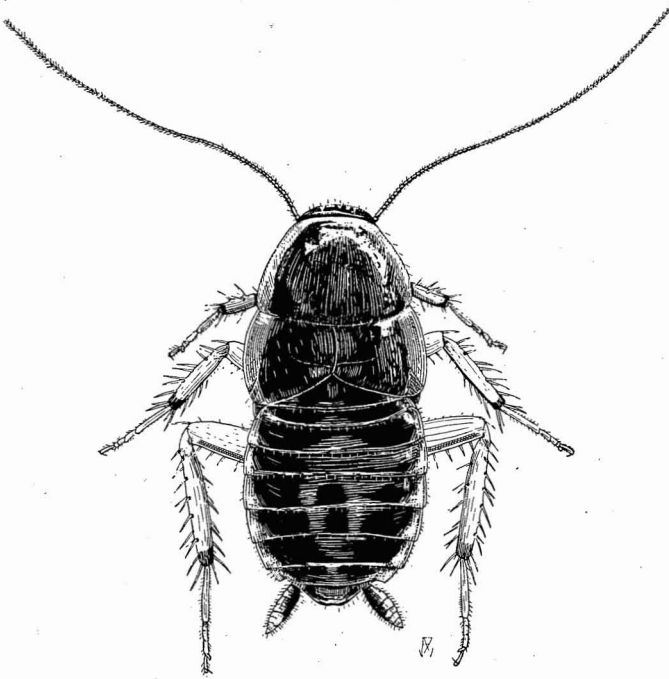


Figure 43—*Lobopectera dimidiatipes* (Bolivar). (From the original drawing by Williams, 1931.)



Figure 44—*Cutilia soror* (Brunner).

## Subfamily BLATTINAE

Genus **CUTILIA** Stål, 1877

**Cutilia soror** (Brunner) (figs. 36, c; 44).

*Polyzosteria soror* Brunner, 1865:219.

Ootheca figured by Williams, 1931, pl. 2, fig. 1.

Kauai, Oahu, Molokai, Lanai, Hawaii, Kahoolawe, Nihoa, Laysan, Kure (Ocean).

Immigrant. Widespread in Oceania, Formosa, Amboina, Ceram, New Caledonia, Loyalty Islands, Fiji, Tonga, Samoa, Ellice Islands, Johnston Island, Wake Island, Society Islands, Marquesas. First recorded from Hawaii by Perkins (1899:6).

Common in bunch grass in drier regions; in decaying logs. Adults brachypterous.

Parasites: *Dolichurus stantoni* Ashmead (Hymenoptera: Ampulicidae), on nymphs; *Evania appendigaster* (Linnaeus) (Hymenoptera: Evaniidae), on eggs.

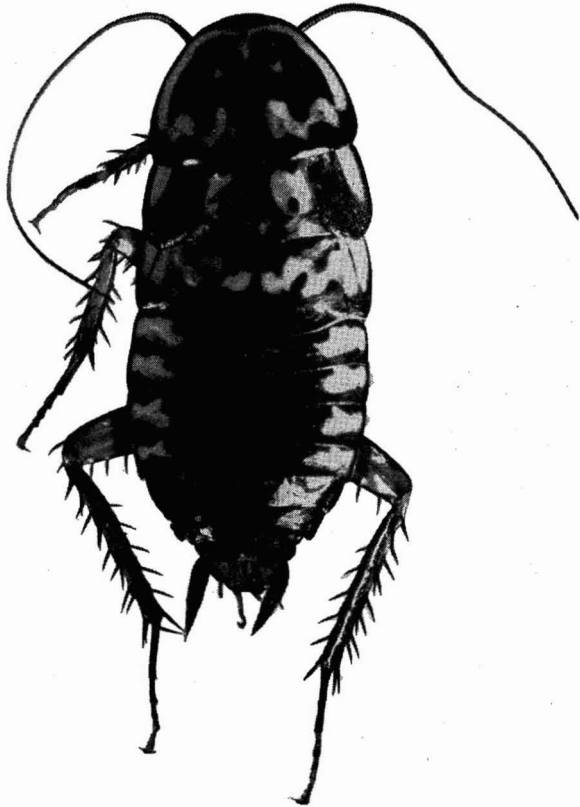


Figure 45—*Neostylopyga rhombifolia* (Stoll), the harlequin cockroach, male.

Genus **NEOSTYLOPYGA** Shelford, 1911

**Neostylopyga rhombifolia** (Stoll) (fig. 45).

*Blatta rhombifolia* Stoll, 1813:5, pl. 3, fig. 13.

*Stylopyga decorata* Brunner, 1865:224.

The harlequin cockroach.

Oahu, Kahoolawe.

Immigrant. An Indo-Malayan species, now tropicopolitan. First recorded from Hawaii by Bormans (1882).

Parasite: *Ampulex compressa* (Fabricius) (Hymenoptera: Ampulicidae) on the adults.

This is another flightless cockroach.

Genus **PERIPLANETA** Burmeister, 1838

Hawaiian name: "elehu-kikeke"

These cockroaches may be controlled by the use of DDT dusts and sprays.

**Periplaneta americana** (Linnaeus) (figs. 36, b; 46).

*Blatta americana* Linnaeus, 1758:424.

Figured by Williams, 1931:52; ootheca, pl. 2, fig. 2.

The American cockroach.

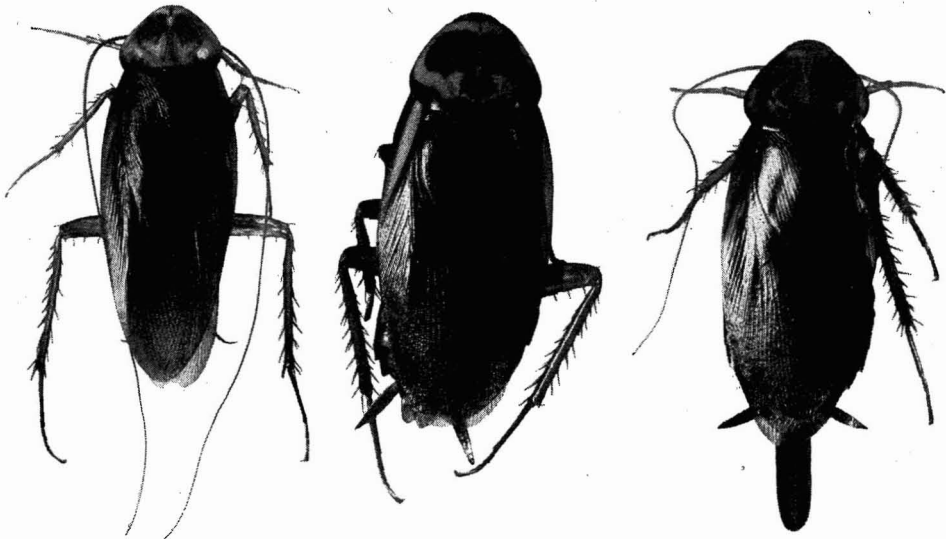


Figure 46—The three species of *Periplaneta* established in Hawaii: *P. americana* (Linnaeus), left; *P. australasiae* (Fabricius), middle; *P. brunnea* Burmeister carrying nearly completed ootheca, right. (Not to same scale.)



Kauai, Oahu, Molokai, Maui, Lanai, Hawaii, Nihoa, Necker, French Frigate Shoal, Laysan, Midway.

Immigrant. Cosmopolitan. A native of tropical Africa. First recorded from Hawaii by Bormans in 1882.

Hostplants: blossoms of *Canna* and *Tribulus*.

Parasites: *Evania appendigaster* (Linnaeus) and *Evania sericea* Cameron (Hymenoptera: Evaniidae), on the eggs; *Ampulex compressa* (Fabricius) (Hymenoptera: Ampulicidae), on nymphs and adults.

This species is a household nuisance.

***Periplaneta australasiae* (Fabricius) (figs. 36, a; 46).**

*Blatta australasiae* Fabricius, 1775:271.

Williams, 1931; pl. 2, fig. 3, ootheca.

The Australian cockroach.

Kauai, Oahu, Molokai, Maui, Lanai, Hawaii, Nihoa, Kure (Ocean).

Immigrant. A tropical African species, now tropicopolitan. Australia, Fiji, Gilbert Islands, Samoa, Tahiti, Marquesas, Tuamotus, Easter Island, Galapagos. First recorded from Hawaii by Perkins (1899:7).

Hostplants: *Pritchardia*, *Sida*.

Parasites: *Evania appendigaster* (Linnaeus) and *Evania sericea* Cameron (Hymenoptera: Evaniidae), in the oothecae; *Ampulex compressa* (Fabricius), on the nymphs and adults.

This is another pest species. I have found these roaches breeding by scores in rock piles accompanied by large numbers of *Scolopendra* centipedes and large spiders (*Heteropoda regia*) which probably prey upon the roaches.

***Periplaneta brunnea* Burmeister (fig. 46).**

*Periplaneta brunnea* Burmeister, 1838:502.

*Periplaneta truncata* Brunner, in Krauss, 1892:165.

*Periplaneta ignota* Shaw, 1925:205.

Oahu.

Immigrant. Tropicopolitan; originally a tropical African form. Australia, New Britain, New Caledonia, Loyalty Islands, New Hebrides, Tonga, Marquesas, tropical America. First recorded from Hawaii by Swezey in 1929.

This is the least common of our *Periplaneta* species.

## Subfamily PANCHLORINAE

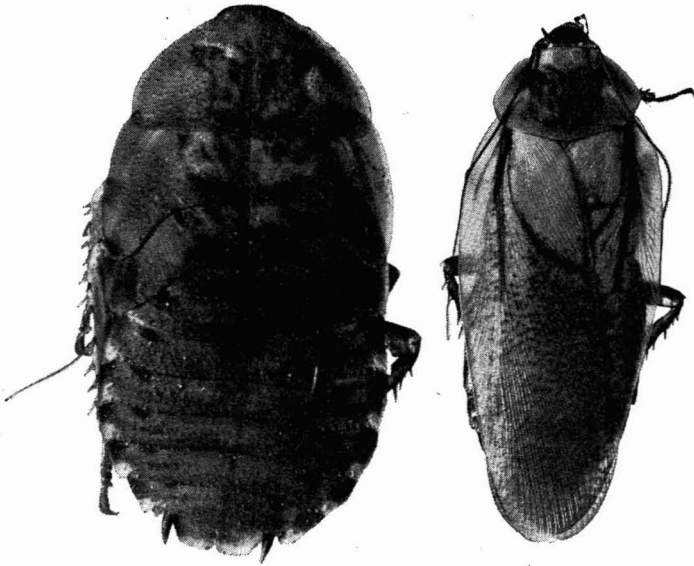
Genus **LEUCOPHAEA** Brunner, 1865**Leucophaea maderae** (Fabricius) (fig. 47).*Blatta maderae* Fabricius, 1793:6.

The Madera (or Madeira) cockroach.

Kauai, Oahu, Molokai, Maui, Hawaii.

Immigrant. A native of West Africa, but now nearly tropicopolitan. Fiji, Philippines, Java. First found in the islands at Molokai in 1896 or 1897 by Schauinsland.

Largest of the Hawaiian cockroaches (40-50 mm. long) ; said to be ovoviviparous. Bionomical studies by Illingworth (1915:137).

Figure 47—*Leucophaea maderae* (Fabricius), nymph and adult. (Not to same scale.)Genus **NAUPHOETA** Burmeister, 1838**Nauphoeta cinerea** (Olivier) (fig. 48).*Blatta cinerea* Olivier, 1789:314.*Nauphoeta bivittata* Burmeister, 1838:508.

The cinereous cockroach.

Oahu, Hawaii.

Immigrant. First recorded from Hawaii by Perkins (1899:7). Tropicopolitan ; an East African species first described from Mauritius. Malaya, Sumatra, Philippines, Australia, New Caledonia.

It is ovoviviparous. Illingworth (1942:169-170) reported finding, by dissection, 28 to 40 eggs in gravid females. He also reported that the species kills and eats the cypress roach (*Diploptera*), that it is omnivorous and that heavy infestations were observed in prepared poultry feed.

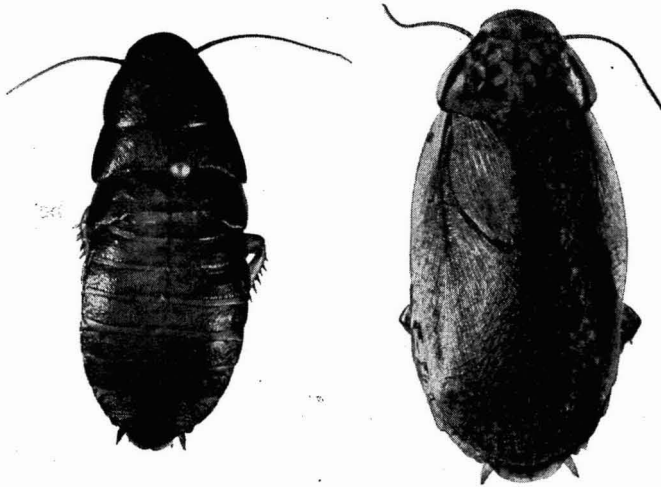


Figure 48—*Nauphoeta cinerea* (Olivier), the cinereous cockroach, nymph and adult.

#### Genus **PYCNOSCELUS** Scudder, 1862

***Pycnoscelus surinamensis*** (Linnaeus) (fig. 49).

*Blatta surinamensis* Linnaeus, 1767:687.

*Blatta punctata* Eschscholtz, 1822:86; described from Hawaii.

Williams, 1931:51, figures nymph and adult.

The burrowing, Surinam or bicolored cockroach.

Kauai, Oahu, Molokai, Maui, Lanai, Hawaii, Nihoa, French Frigate Shoal, Pearl and Hermes Reef.

Immigrant. The first cockroach recorded by name from Hawaii (Eschscholtz: 1822). An Oriental species, now tropicopolitan. Indo-Pacific, Society Islands, Caroline Islands, Fiji, Tonga, Samoa, Gilbert Islands, Johnston Island, New Caledonia, Loyalty Islands, New Hebrides, Marquesas, Tuamotus, Galapagos.

Hostplants: blossoms of *Tribulus*; reported feeding at roots of pineapples, and unconfirmed reports of damage to underground parts of some other plants. Hoffman (1927) reports damage to rose roots and to potato tubers in Haiti. It acts more like a scavenger than a regular feeder on fresh plant material, however.

Ovoviviparous; reported to be parthenogenetic in some localities; abundant in loose soil, under stones, under boards and other objects lying on the ground, in trash and similar situations, in drier areas especially; nymphal period, 10 months.

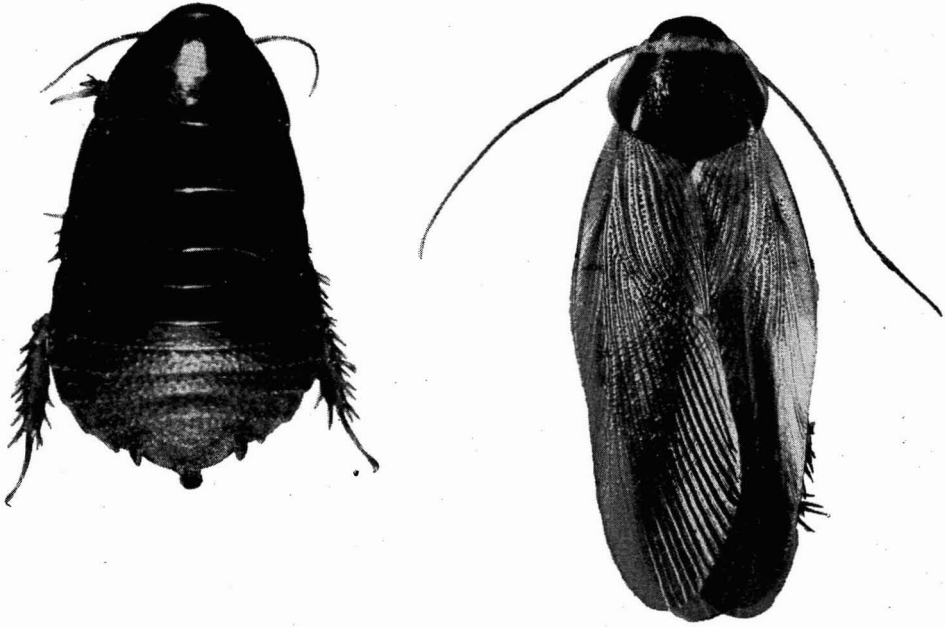


Figure 49—*Pycnoscelus surinamensis* (Linnaeus), the burrowing cockroach, nymph and adult.

Parasites: none recorded in Hawaii, but *Sarcophaga sternodontis* (Townsend) (= *lambeus* Weideman) (Diptera) might be introduced from the West Indies to aid in control. In the West Indies, Hoffman (1927) found 40 percent of the roaches parasitized. The parasite also attacks a host of other insects including Scarabaeidae, Pentatomidae and Lepidoptera.

Predators: sparrows, mynah birds, barnyard fowls, toads (at times, 40–50 percent of the diet of the imported toad, *Bufo marinus*, is reported to be this roach).

Veterinary importance: This species is an intermediate host of Manson's eye worm of poultry. Chickens should be kept off the ground to prevent their eating the roaches and becoming parasitized. The worms have been found in the legs, abdomens and thoraxes of the cockroaches.

Control: This roach usually becomes so abundant in poultry yards that control is recommended. Alicata (1938) reports that "butyric fermentation baits were in some cases found effective in capturing up to about 700 roaches in a single trap. Each trap consisted of a wide-mouthed glass jar about 9 inches high and 5 inches wide, which contained the bait. This trap was set in the ground so that the mouth opening of the jar was at a level with the surface of the ground." Carbon bisulfide and a spray of Diesel oil have been used successfully. Cleanliness will go far toward keeping the roach populations down, but accumulations of manure and debris will encourage the building up of large numbers of roaches. DDT sprays and dusts are recommended for control.

Genus **DIPLOPTERA** Saussure, 1864

*Eleutheroda* Brunner, 1865.

**Diploptera dytiscoides** (Serville) (fig. 50).

*Blatta dytiscoides* Serville, 1839:102.

*Eleutheroda dytiscoides* (Serville) Brunner, 1895:893.

Chopard, 1929:22, fig. 14. Williams, 1931, figs. 7, 12.

The cypress cockroach.

Kauai, Oahu, Molokai, Lanai, Maui, Hawaii.

Immigrant. Widespread in the Indo-Pacific, India, Ceylon, Singapore, Australia, Fiji, Samoa, Society Islands, Marquesas, Easter Island. First reported from Hawaii by Bormans in 1882.

Hostplants: *Cupressus macrocarpa*, *Casuarina*, *Cryptomeria*, *Citrus*, geraniums, *Acacia farnesiana* pods, mango fruits, orange fruits, papaya fruits; damages cypress, *Prosopis*, lime and some other plants by girdling and killing the twigs and limbs. The dead, drying, brown branches are often conspicuous on cypress trees and cause considerable concern to garden lovers.

Control: It is not an easy insect to control, but the use of stomach poison sprays and poison baits such as phosphorus paste on bread placed in protected containers

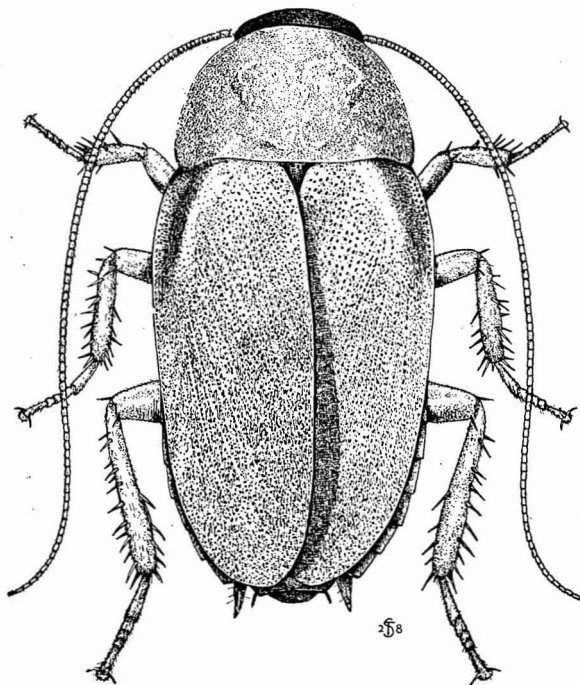


Figure 50—*Diploptera dytiscoides* (Serville), the cypress cockroach. (From Twigg-Smith's original drawing for Williams, 1931.)

on attacked plants are possible measures. Dusting infested trees with sodium fluoride powder or DDT and reducing their numbers by beating them off plants after dark and destroying the catch will give some aid. Dusting or spraying must be repeated frequently if control is to be attained, however.

Predators: toads and geckoes.

Ovoviviparous: embryological studies by Hagan (1939:264).

Subfamily CORYDIINAE

Genus **EUTHYRRHAPHA** Burmeister, 1838

**Euthyrrhapha pacifica** (Coquebert) (figs. 36, d; 51).

*Blatta pacifica* Coquebert, 1804:91, pl. 21, fig. 1.

Williams, 1931, pl. 2, fig. 5, ootheca.

The Pacific cockroach.

Kauai, Oahu, Maui, Hawaii.

Immigrant. First recorded from Hawaii by Bormans in 1882. Almost tropicopolitan.

This handsome little species is diurnal in habit and may frequently be seen in its rapid, erratic flight in the fields of drier areas. Its actions are not "typically" cockroach-like, and it is not infrequently confused with the beetles by laymen.

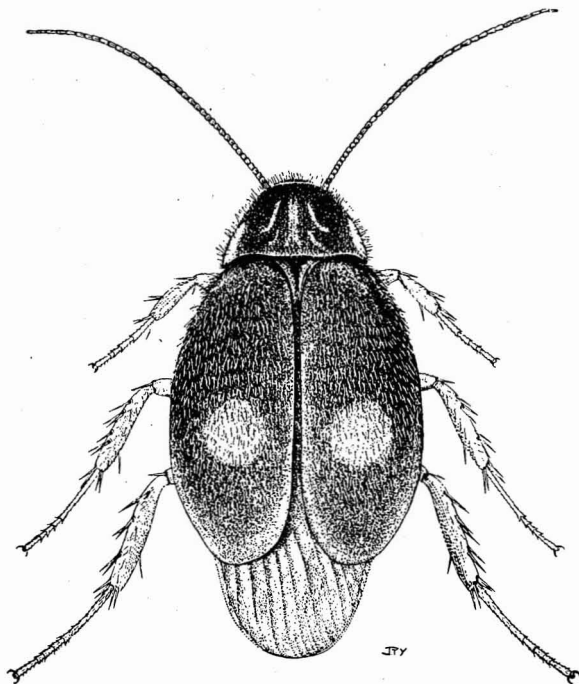


Figure 51—*Euthyrrhapha pacifica* (Coquebert), the Pacific cockroach. (From Yamamoto's original drawing for Williams, 1931.)

Genus **HOLOCOMPSA** Burmeister, 1838

**Holocompsa fulva** (Burmeister) (fig. 52).

*Corydia fulva* Burmeister, 1838:492.

Hawaii.

Immigrant. Ethiopian. First recorded from Hawaii by Illingworth (1916:254), but Perkins found it common at Hilo in August, 1900.

This is the smallest cockroach found in Hawaii, for it is only about 5 mm. in length. It is not often collected here. The brachypterous females produce tiny oothecae (about 2 mm. long).



Figure 52—*Holocompsa fulva* (Burmeister).

In addition to these species, Bormans (1882) recorded *Oniscosoma pallida* Brunner (1865:343) from material supposedly collected by Blackburn on Haleakala, Maui. This species has not been found since in Hawaii and is, therefore, omitted from this list. The record might have been based upon a mislabeled or misidentified specimen.

### Suborder GRESSORIA (Fieber)

Family MANTIDAE Saussure, 1869

Mantids, Praying Mantids, Soothsayers

Large, comparatively slow-moving, elongate insects; head exposed, mobile, vertical, large, broader than long, flexibly attached to prothorax by a short neck; antennae inserted between the eyes, filiform, less than one-half as long as body,

segments multitudinous; compound eyes large, prominent, fronto-lateral, sub-hemispherical; with three ocelli on a triangular prominence above and between antennal bases; mandibles large, dentate; maxillary palpi five-segmented; labial palpi three-segmented; pronotum longer than broad or greatly elongate and several times longer than broad, neck-like; fore wings in our species with only anterior margins tegmenized, elsewhere membranous and with well-defined venation; hind wings well-developed; abdomen with 10 tergites, nine ventrites in males, seven ventrites in females, but the first ventrite usually reduced so that only eight or six ventrites are distinct, cerci segmented, male with styli; ovipositor wanting; legs with anterior pair greatly modified, raptorial; fore coxae elongate, femora-like; fore femora elongate, with an armature of teeth along ventral margin; fore tibiae shorter than femora, also armed below, capable of closing on femora, strongly uncinat; mid and hind legs not so modified, coxae normal, femora and tibiae elongate, slender; tarsi five-segmented, first four segments with pulvilli; paired tarsal claws without arolia between them; oviparous, eggs deposited in oothecae.

There are three species of Mantidae found in Hawaii, but all are immigrants, and each belongs to a different genus.

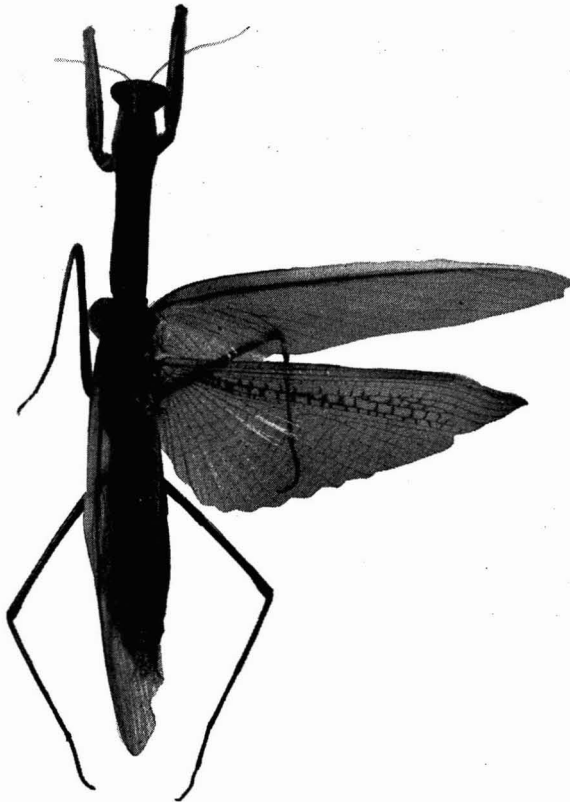


Figure 53—*Tenodera angustipennis* Saussure, a praying mantid.



Some of the most curious members of the insect world are found in the mantid family, but the species found in Hawaii are neither greatly specialized nor unusual. The group is essentially tropical.

At egg laying, the female produces a foamy substance which surrounds the eggs, dries on exposure and forms the ootheca. The eggs are so deposited and the "foam" so controlled and manipulated by the end of the abdomen and the apices of the wings that the end product is a well-formed, characteristic, hardened papier maché-like ootheca in which the eggs are enclosed in more or less symmetrical chambers. The oothecae are fastened to limbs, twigs, posts and other objects.

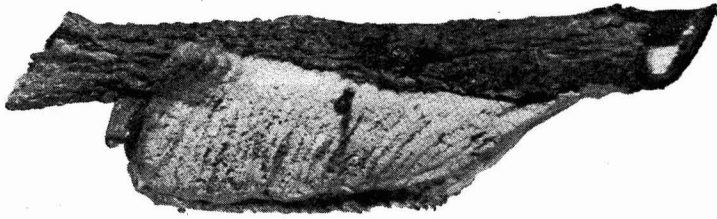


Figure 54—Ootheca of *Tenodera angustipennis* Saussure.

Mantids are voracious insect tigers, and their predaceous habits place them among our beneficial insects. Hadden (1927) has listed 29 species in five orders of insects seen by him to be eaten by one of our mantids (*Tenodera*). They attack nearly all kinds of arthropods that come their way. Their common name is derived from the attitude they assume when at rest or when awaiting some hapless insect that may chance within striking distance: the fore legs are so held as to make the insect look as if it were praying instead of preying.

The coloration of our species makes them inconspicuous among the foliage on which they live.

In many regions, mantids are considered sacred, are worshiped, or are looked upon with awe, and many local myths and much superstition is connected with them.

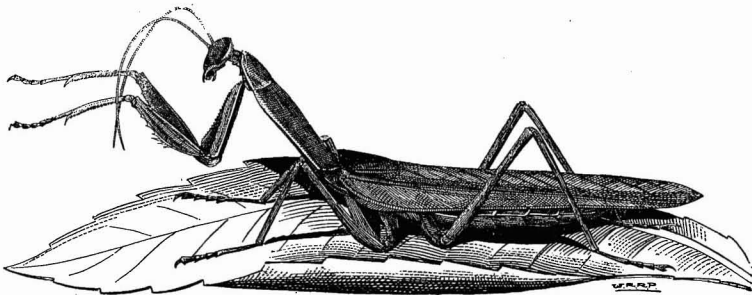


Figure 55—*Tenodera angustipennis* Saussure, natural size, awaiting the approach of prey. (After Kirkaldy, 1909.)

## KEY TO THE MANTIDS FOUND IN HAWAII

1. Pronotum not more than twice as long as broad, broadest at apex, apex broadly and only slightly arcuate, subtruncate; length about 40 mm.; subfamily Eremiaphilinae.....  
.....**Orthodera ministralis** (Fabricius).  
Pronotum slightly more than twice as long as broad to more than four times as long as broad, broadest at a distance behind apex above insertion of coxae, apex conspicuously rounded; length 65–90 mm.; subfamily Mantinae..... 2
2. Pronotum about four times or more than four times as long as broad; length of insect 80–90 mm.....  
.....**Tenodera angustipennis** Saussure.  
Pronotum slightly more than twice as long as broad; length of insect less than 70 mm.....**Hierodula patellifera** (Serville).

## Subfamily EREMIAPHILINAE

Genus **ORTHODERA** Burmeister, 1838**Orthodera ministralis** (Fabricius).*Mantis ministralis* Fabricius, 1775:277.*Orthodera prasina* Burmeister, 1838:530.

Kauai.

Immigrant. Australia. First recorded in Hawaii from Kauai by Perkins as "introduced with fruit trees" (1899:7).

Prey: *Coelophora inaequalis* (Fabricius) (Coleoptera: Coccinellidae) and many other kinds of insects not yet recorded in our literature.

I have seen only a few examples of this species, and none has been in satisfactory condition to photograph.

## Subfamily MANTINAE

Genus **TENODERA** Burmeister, 1838**Tenodera angustipennis** Saussure (figs. 53, 54, 55).*Tenodera angustipennis* Saussure, 1869:69.

This species has been called *Tenodera sinensis* Saussure and *Paratenodera sinensis* (Saussure) in Hawaii by error of identification.

Jones, 1933:1, pl. 1, figures adult and egg mass. Rehn, 1933:4, gives differences between *T. angustipennis* and *T. sinensis*.

Kauai, Oahu, Molokai, Maui, Lanai, Hawaii.

Immigrant. China, Japan, Java, North America (recent immigrant). First found on the island of Hawaii in 1900, according to Perkins (1910:689).

Introduced from Hawaii to Oahu; established on Oahu in 1918. May produce several oothecae at 10-day intervals, each ootheca containing up to about 300 eggs. See Hadden (1927) for list of prey.

Parasites: *Podagrion mantis* Ashmead (Hymenoptera: Callimomidae) and *Cerambycobius cushmani* Crawford (Hymenoptera: Eupelmidae).

Predators: cardinal birds.

### Genus **HIERODULA** Burmeister, 1838

**Hierodula patellifera** (Serville) (fig. 56).

*Mantis patellifera* Serville, 1839:184.

Kauai.

Immigrant. Java, Philippines. First collected by Swezey on Kauai in 1924.

The males collected here are brown and the females green.

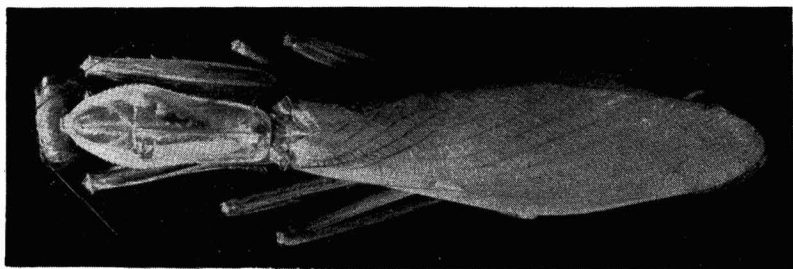


Figure 56—*Hierodula patellifera* (Serville).

### Suborder **SALTATORIA** (Latreille, 1817)

#### Family **ACRIDIDAE** von Siebold, 1848

*Acridiodea*

*Acridiidae*

*Locustidae*

#### Grasshoppers, Locusts, Short-horned Grasshoppers

Leaping insects; head exposed, face vertical or almost horizontal; antennae filiform, moniliform or setaceous, inserted between the eyes, not longer than head and thorax in our species; with less than 25 segments, segments distinct; compound eyes large; three ocelli present, in our species one situated on the mid-line of the face below antennae, and one on either side above antennae; mandibles large, prominent, dentate; maxillary palpi five-segmented; labial palpi three-segmented; pronotum saddle-like; tegmina and wings, when at rest, folded in such a way as to protect partially the sides as well as dorsum of abdomen and fitting together in a vertical plane at apex beyond end of abdomen; abdomen 11-segmented, usually with nine completely visible tergites, males with nine entire ventrites, females with seven entire ventrites; cerci not distinctly segmented; ovipositor short but visible,

composed of four sclerites; tympana large, situated on sides of first abdominal segment; fore and middle legs short, similar; hind femora greatly enlarged for leaping; hind tibiae elongate; tarsi three-segmented, first two segments with pulvilli; claws divergent; arolium present; oviparous, eggs deposited in clusters in soil; diurnal insects.

Fossil acridids have been found in Tertiary (Oligocene, Miocene, Pleistocene) and Recent horizons.

Only three grasshoppers are found in Hawaii; all of them are immigrants.

Most of us are exposed to grasshoppers early in our entomological careers, for these insects have been used in beginning courses in zoology and entomology for several generations.

A number of the world's worst insect pests are included in this family. And it is to this family that the migratory or plague locust of historical and modern times belongs. The student is referred to some standard text for detailed discussions and guides to the literature if he wishes to study the extra-Hawaiian members of the group in detail (Uvarov, 1928, gives detailed information on some of the most economically important species together with general details).

Grasshoppers are vegetarians, and we in Hawaii are fortunate that the three species we have are not such bad pests as they might be. Our species do cause some damage to a number of crops and garden plants, but, broadly speaking, they are insects of weeds and wayside grasses and do comparatively small amounts of damage when compared with their notoriously destructive allies elsewhere.

Grasshoppers may be controlled by the use of stomach poison sprays, or poison baits. A number of parasites and predators act to control the populations of our species. Known parasites and predators from other countries might be introduced to Hawaii in the future to restrict further the development of the Hawaiian forms.

At egg laying, the female forms a cavity in the soil by use of her abdomen. The eggs are then deposited in the hole in a frothy substance similar to that from which the oothecae of the mantids is composed.

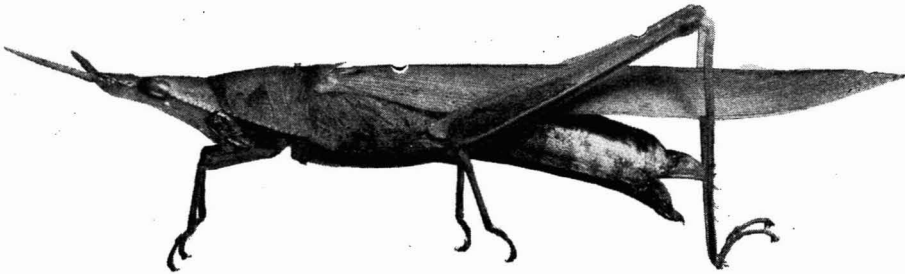


Figure 57—*Atractomorpha ambigua* Bolivar, the slant-faced grasshopper, female.

## KEY TO THE SUBFAMILIES FOUND IN HAWAII

1. Front of head oblique, more nearly horizontal than vertical, meeting top of head at an acute angle, head pointed and produced beyond eyes; clypeus not below eyes, but at a distance behind a line drawn perpendicular to them.... **Pyrgomorphinae.**
2. Front of head more nearly vertical than horizontal, rounded into top of head; clypeus directly below eyes.....  
..... **Cyrtacanthacridinae.**

## Subfamily PYRGOMORPHINAE

## The Slant-faced Locusts

Genus **ATTRACTOMORPHA** Saussure, 1861**Atractomorpha ambigua** Bolivar (fig. 57).

*Atractomorpha ambigua* Bolivar, 1905:209.

Called *A. crenaticeps* Blanchard, in earlier Hawaiian literature because of an error in determination. Williams, 1931:62, fig. 16.

The slant-faced grasshopper, pink-winged grasshopper, pink-winged tryxalid.

Kauai, Oahu, Molokai, Maui, Hawaii.

Immigrant. China, Japan, Australia. First recorded from Hawaii (Oahu) by Kotinsky in 1906, but known to have been found here in 1900. (A specimen in Perkins' collection at Bishop Museum is noted by Perkins as the "first caught specimen Govt. nursery in 1900.") First recorded on Kauai by Swezey in 1918.

Hostplants: *Scaevola chamissoniana*, pineapple, broccoli, celery, garden beans, Chinese and other cabbage, New Zealand spinach, potato, many kinds of weeds and garden plants.

Predators: English sparrow, Brazilian cardinal.

Bionomical studies by Swezey (1907:106). Dichromatic, gray or green; eggs laid in December and January; egg mass in soil, cylindrical, 4 × 12 mm., contains 27-38 dull yellowish eggs 1 × 4 mm.; egg stage 47-49 days; 5-6 molts; instars 10-20 days each; life cycle 5 months.

## Subfamily CYRTACANTHACRIDINAE

## The Spine-breasted Locusts

## KEY TO THE GENERA ESTABLISHED IN HAWAII

1. Adults fully winged ..... **Oxya** Serville.
2. Adults without wings..... **Paraideмона** Brunner.

Genus **OXYA** Serville, 1831

**Oxya chinensis** (Thunberg) (figs. 58; 59, 1-4).

*Gryllus chinensis* Thunberg, 1815:253.

Listed in earlier Hawaiian literature as *Oxya velox* (Fabricius) because of error of identification. Willemse, 1925:49, figs. 54-57. Swezey, 1926:378, fig. 1, adult, egg mass, damage to sugarcane.

The Chinese grasshopper.

Kauai, Oahu, Maui, Hawaii.

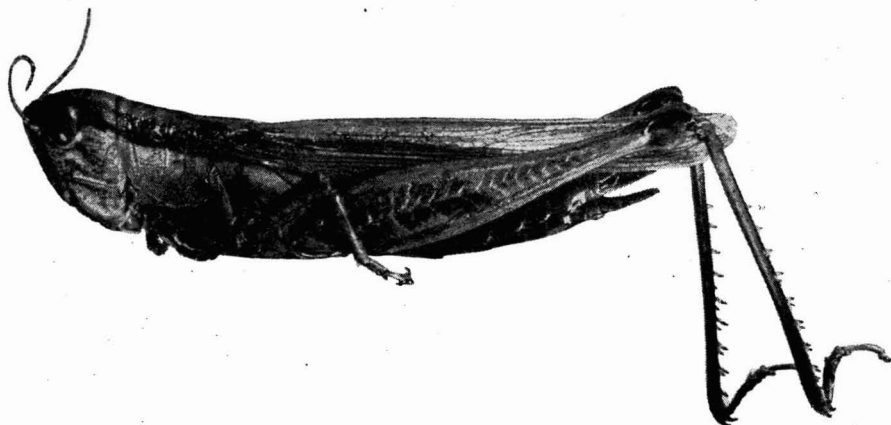


Figure 58—*Oxya chinensis* (Thunberg), the Chinese grasshopper, female.

Immigrant. Widespread in India, Burma, Ceylon, Siam, China, Japan, Mauritius, Malay Peninsula, Sumatra, Borneo, Java, Philippines, Moluccas, Celebes, New Britain, Australia. Found in Hawaii before 1892; first recorded by Brunner (1895:893). Known from Kauai and Oahu in 1897; first found on Maui in 1918 and on Hawaii in 1925.

Hostplants: grasses, Job's tears, nutgrass, *Panicum purpurascens*, *Passiflora*, pineapple, potato, rice, sugarcane (produces ragged leaves and may cause minor checking of growth; occasionally does severe local damage, especially adjacent to rich patches of nutgrass, where populations build up).

Parasites: *Tachysphex fuscus* Fox (Hymenoptera: Sphecidae) on nymphs; *Scelio pembertonii* Timberlake (Hymenoptera: Scelionidae) on eggs; a *Gordius* roundworm. Pemberton made a trip to the Malay Peninsula in 1930-31 to search for parasites and introduced the *Scelio*.

Predators: sparrows, mynah birds.

Bionomical studies by Swezey, 1926:378. Egg masses contain about 20 eggs, as many as three batches per female, usual incubation period six weeks, but delayed hatching up to 277 days recorded; seven molts; 10-16-day instars; nymphal period 6-10 weeks; adults live two to three months; two broods per year.

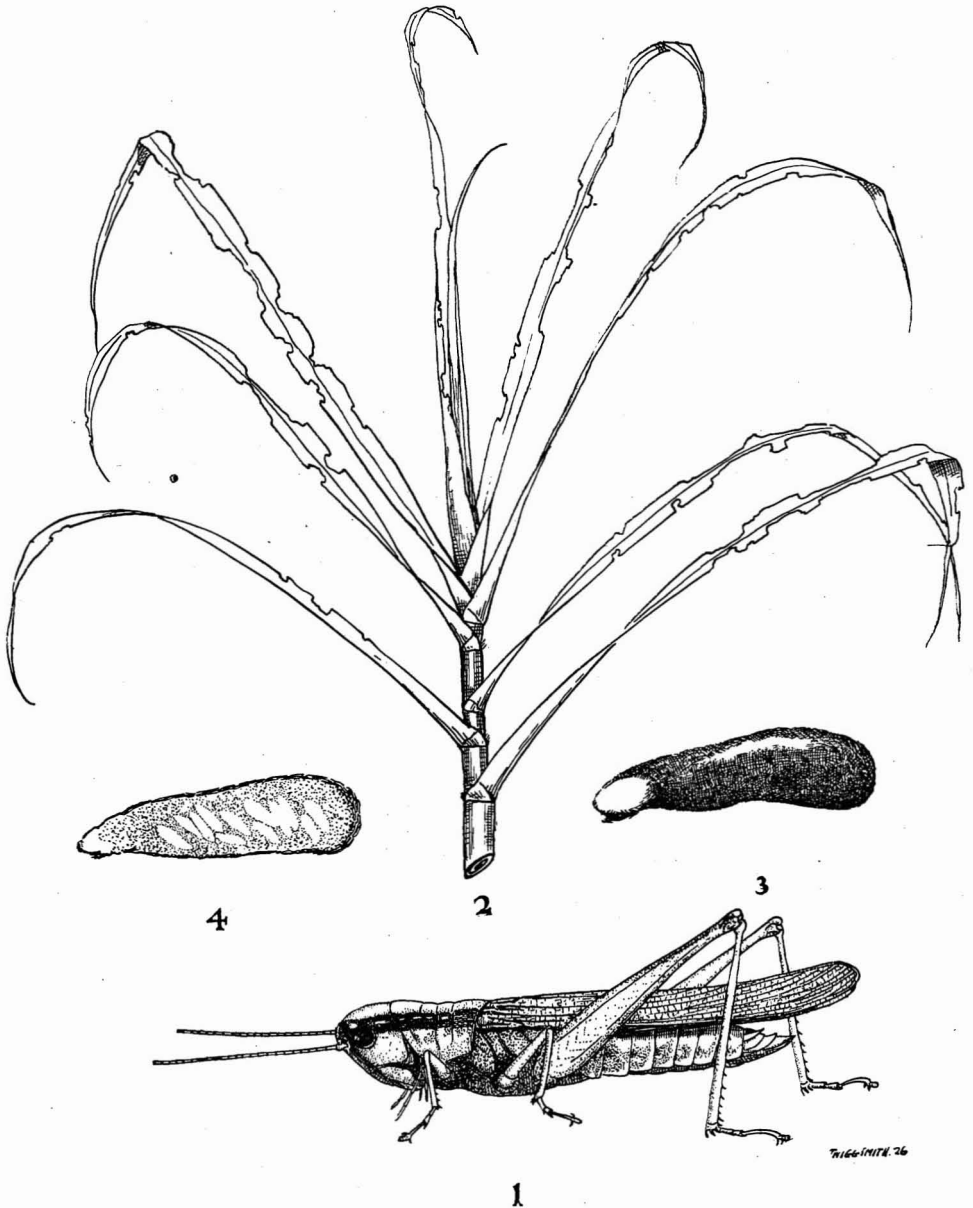


Figure 59—*Oxya chinensis* (Thunberg), the Chinese grasshopper. 1, adult female; 2, typical damage done to the leaves of a young sugarcane shoot; 3, egg mass; 4, egg mass sectioned to show the enclosed eggs. (After Swezey, 1926.)

Genus **PARAIDEMONA** Brunner, 1893

This is a northern Mexican and Texas genus.

***Paraidemona mimica*** Scudder (fig. 60).

*Paraidemona mimica* Scudder, 1898:43, pl. 3, fig. 10.

Oahu.

Immigrant. Described from Texas. First discovered at Hickam airfield, Honolulu, in July, 1945, by C. E. Pemberton.

Hostplants: grasses.

This species has become established through the importation of materials of war, and it will bear close watching.



Figure 60—*Paraidemona mimica* Scudder, male.

Family **TETTIGONIIDAE** Karny, 1903

*Locustidae* Burmeister, 1838.

*Phasgonuridae*.

## Katydids, Longhorned Grasshoppers

Leaping insects; head exposed, prominent; antennae elongate, longer than body, filiform, multisegmented, inserted between eyes; compound eyes large; ocelli absent; mandibles large, prominent, dentate; maxillary palpi five-segmented; labial palpi three-segmented; pronotum large, saddle-like; tegmina and wings fully developed or brachypterous, held roof-like over after-body and projecting far beyond apex of abdomen when fully developed; tegmina usually leaf-like in appearance, not heavily sclerotized; hind wings, when fully developed for flight, projecting a short distance beyond apices of tegmina; bases of tegmina in male modified to form stridulating organs; abdomen 10-segmented, with nine complete tergites visible; males with nine complete ventrites, the ninth enlarged and modified, female with seven; ovipositor conspicuous, long, strongly developed, heavily sclerotized, blade-like, composed of six compactly placed sclerites; male genitalia large, conspicuous (Phaneropterinae with two elongate, ventral processes somewhat resembling an ovi-



positor); cerci not segmented; hind legs with femora and tibiae elongate, much longer than others, hind femora modified for leaping; fore tibiae bearing tympanal organs just below articulation with femora; tarsi four-segmented, first three segments with pulvilli; tarsal claws divergent or divaricate, with empodia; oviparous, eggs inserted in plant tissues; nocturnal insects of herbivorous, omnivorous or predaceous habit.



Figure 61—*Elimaea punctifera* (Walker), the narrow-winged katydid, female.

There have been 16 katydids and longhorned grasshoppers recorded from Hawaii. The family reaches its greatest diversity in the tropics, and there are more than 7,000 species described from the world. The Hawaiian fauna contains two groups, one immigrant with four species in four genera, the other endemic with 11 species and one variety in two genera, both of which are endemic.

The katydids are well-known insect musicians, and their stridulated songs have been the subject of much study and comment for ages. Stridulation is a male attribute and is accomplished by rubbing the specialized bases of the tegmina together. The underside of the stridulating organ on the left tegmen is armed with small denticles which are rubbed across a drum-like membrane on the right tegmen to produce the characteristic song or chirping of the species. Our Phaneropterinae are our best songsters among the Tettigoniidae.

In other countries large and queer forms are found, and some apterous, pale, blind species dwell in perpetual darkness and make up a dominant part of the faunas of certain limestone caverns.

The Hawaiian katydids are all found on small plants, shrubs or trees. None of them is terrestrial. *Banza* has reduced wings and does not fly, but the species of the other genera are active fliers.

The large, blade-like ovipositors of the females enable them to make incisions in the stems of many kinds of plants into which the eggs are inserted. This habit causes some injury to certain plants.

The Hawaiian species include no serious pests, but damage of a minor sort, or of restricted serious nature, is on occasion caused by some of the adventitious species. Stomach poison sprays will aid in the control of katydids when they are found causing significant damage. At least one of our immigrant species (*Xiphidiopsis*) is more beneficial than detrimental, for it prefers an insect diet.

A number of predators and parasites attack katydids, and those found in Hawaii are listed in the text beneath the species headings.

KEY TO THE SUBFAMILIES OF TETTIGONIIDAE FOUND IN HAWAII

1. Prosternum without a pair of long sharp spines..... 2  
 Prosternum with a pair of distinct spines..... 3
- 2(1). Fore tibiae with spines along inner edge shorter than breadth of tibia at middle; tympanum enclosed, opening through a longitudinal, outward-facing slit on either side of tibia, or at least enclosed on one side..... **Phaneropterinae.**  
 Fore tibiae with long, strong, prominent spines along lower edge which are obviously longer than breadth of tibia at middle; tympanum entirely open, oval and "window-like"  
 ..... **Listrocelinae.**
- 3(1). Fore and/or mid femora with at least a few stout, tooth-like spines along anterior ventral margin toward apex, hind femora with similar, more numerous spines along both inner and outer ventral margins in distal half, but those on outer margin less numerous or only a few toward apex; distance from a line drawn between anterior edges of eyes to apex of fastigium much greater than length of eye, as viewed from above (in other words, the fastigium is much more protuberant); all but one of our species flightless  
 ..... **Copiphorinae.**  
 Fore and mid femora without any such spines, hind femora with only a few widely spaced spines in a single row; distance from fore edges of eyes to apex of fastigium much shorter than length of eye..... **Conocephalinae.**

Subfamily PHANEROPTERINAE

KEY TO THE GENERA AND SPECIES FOUND IN HAWAII

1. Broadest part of tegmina obviously narrower than distance between metacoxa and top of pronotum; tympanum completely and equally enclosed on both faces of tibia.....  
 ..... **Elimaea punctifera** (Walker).
2. Broadest part of tegmina about as broad as height of metathorax from coxa to top of pronotum; tympanum almost entirely open on posterior side of tibia.....  
 ..... **Holochlora japonica** Brunner.

Genus **ELIMAEA** Stål, 1874

**Elimaea punctifera** (Walker) (figs. 61, 62).

*Phaneroptera punctifera* Walker, 1869:342.

*Elimaea appendiculata* Brunner, 1878:101 (reference not seen).

The narrow-winged katydid.

Oahu, Molokai, Hawaii.

Immigrant. India, Burma, Malay Peninsula, Java, Borneo. First recorded from Hawaii by Bormans (1882).



Figure 62—*Elimaea punctifera* (Walker), the narrow-winged katydid, feeding on a flower bud of hibiscus. (After Williams, 1931.)

Hostplants: *Hibiscus*, young avocado leaves, garden beans, coffee, cotton, *Canna*, *Azalea*. It sometimes causes severe damage by destroying buds of *Hibiscus*, eating *Canna* and other blossoms, and damaging the blossoms of mango.

The eggs are deposited in slits in leaf margins of various plants, in tender young shoots of avocado, in fern fronds or other plants, and some injury may be caused by egg laying.

Parasites: *Anastatus koebelei* Ashmead (Hymenoptera: Encyrtidae), *Ufens elimaeae* Timberlake (Hymenoptera: Trichogrammidae), both egg parasites.

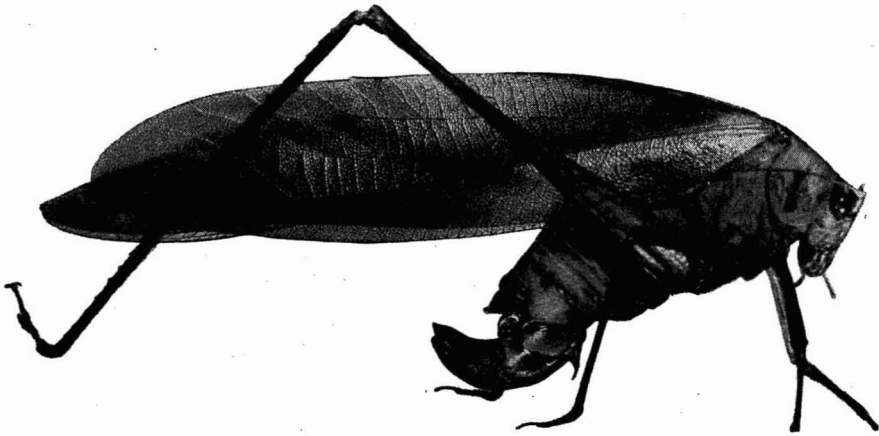


Figure 63—*Holochlora japonica* Brunner, the broad-winged katydid, female.

Genus **HOLOCHLORA** Stål, 1873

***Holochlora japonica*** Brunner (figs. 63, 64, 65).

*Holochlora japonica* Brunner, 1878:181.

*Holochlora venosa* Stål, 1873:43.

The broad-winged katydid.

Oahu, Kauai.

Immigrant. China, Japan, Sumatra, Java. Established in Hawaii about 1896.

Hostplants: *Hibiscus* (damage severe at times), young mango leaves (sometimes damages the flower clusters), *Canna* and other blossoms.

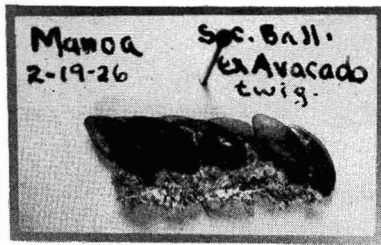


Figure 64—Eggs of *Holochlora japonica* Brunner.

Eggs flat, seed-shaped, as many as one hundred deposited in double rows in slits in young shoots of mango, orange, *Sapindus oahuensis*, *Hibiscus*, *Bougainvillea*, avocado, *Ficus* and cactus. Some injury is done by oviposition.

Parasites: *Zaischnopsis* sp. (see Swezey, 1944:137), *Anastatus koebelei* Ashmead (Hymenoptera: Encyrtidae), *Ufens elimaeae* Timberlake (Hymenoptera: Trichogrammidae).

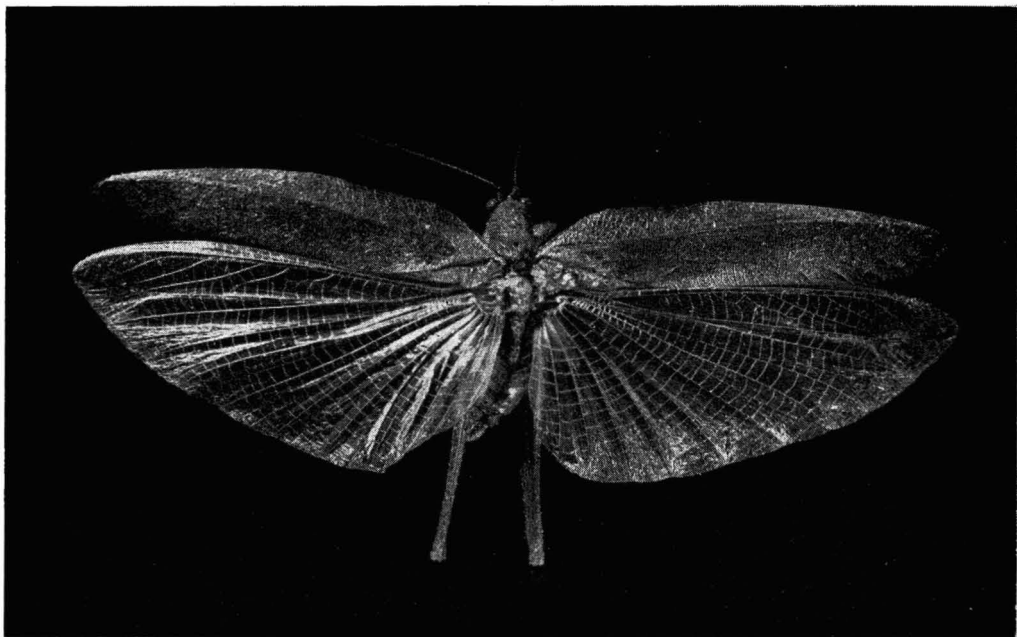


Figure 65—*Holochlora japonica* Brunner, male.

#### Subfamily COPIPHORINAE

##### KEY TO THE GENERA FOUND IN HAWAII

1. Tegmina and hind wings fully developed for flight.....**Conocephaloides** Perkins.
2. Tegmina and/or wings greatly reduced, not useful for flight  
.....**Banza** Walker.

##### Genus **CONOCEPHALOIDES** Perkins, 1899:13

This genus was described by Perkins as an endemic genus which formed a connecting link between the native *Banza* and the essentially tropicopolitan *Conocephalus*. He also considered that *Banza* was derived from "some such form as the genus *Conocephaloides*" (1899:2), and later (1913:ccxv) he restated his opinion by saying that *Conocephaloides* was "a form such as one might suppose gave rise to the more remarkable *Banza*." The basis for his description was a single female taken at Olaa, Hawaii, at 2,000 feet elevation. In Kirby's catalog (1906:251), Perkins' species is listed as a synonym of *C. remotus* (Walker), which synonymy Perkins acknowledged without remark (1913:ccxv). In the same reference Perkins said that the species "seems now to be very rare, but was probably once abundant, and has been destroyed by introduced predaceous insects." Considerable collecting has been done in the type locality and no additional specimens have been recovered. Olaa is in the vicinity of homesteads and sugar plantations which were

active in that neighborhood in Perkins' time. This fact, together with the capture of a single specimen, at first led me to believe that it would be found that the insect was an immigrant that failed to become permanently established. In later years Perkins collected a single specimen of *Conocephaloides* near the coast of West Maui and three specimens at 2,000 feet on Lanai. These four specimens are now in the Bishop Museum, and they bear a note by Perkins which reads, "These sp. want comparison as being possibly modified spp. or races. None has the markings of my *hawaiiensis*." No date of collection is given for any of them. The three specimens collected on Lanai were originally preserved in alcohol and are all much faded and somewhat distorted.

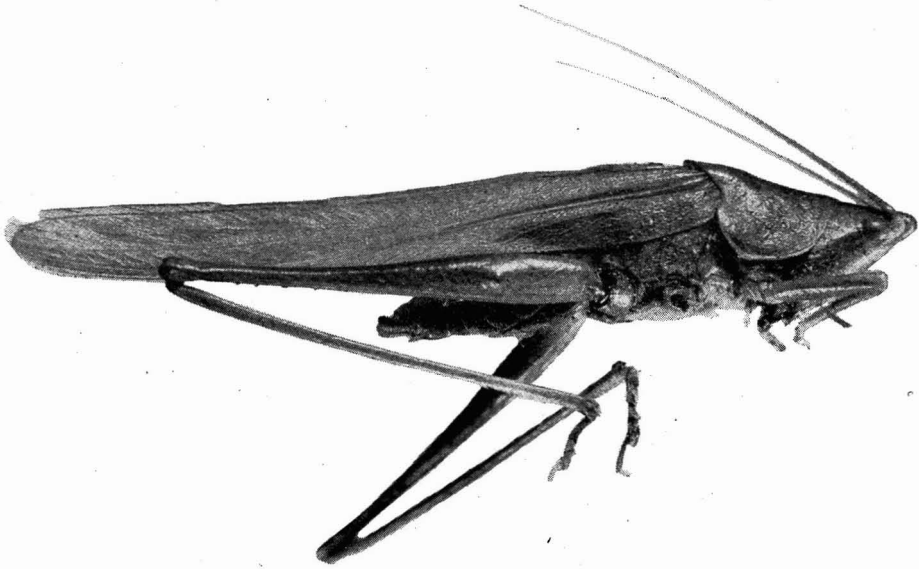


Figure 66—*Conocephaloides remotus* (Walker), male. (This example was taken by Perkins, near the coast on West Maui.)

***Conocephaloides remotus* (Walker) (figs. 66, 67).**

*Conocephalus remotus* Walker, 1869:326 (reference not seen).

*Conocephaloides hawaiiensis* Perkins, 1899:13, pl. 1, fig. 8 (type locality: Oloa, Hawaii, 2,000 feet).

*Conocephaloides remotus* (Walker) Kirby, 1906:251.

Endemic. Maui, Lanai, Hawaii (type locality on Hawaii unknown to me).

The habits of this species are probably such that it might not be collected by casual search during the daytime. Also, there are no resident entomologists in the areas where specimens have been previously collected. I cannot say, therefore, whether or not this species still lives on the adjacent islands of Hawaii, Maui and Lanai, or whether for some unknown reason it has become extinct. It would be worth while to make a special effort to rediscover the species by listening for its

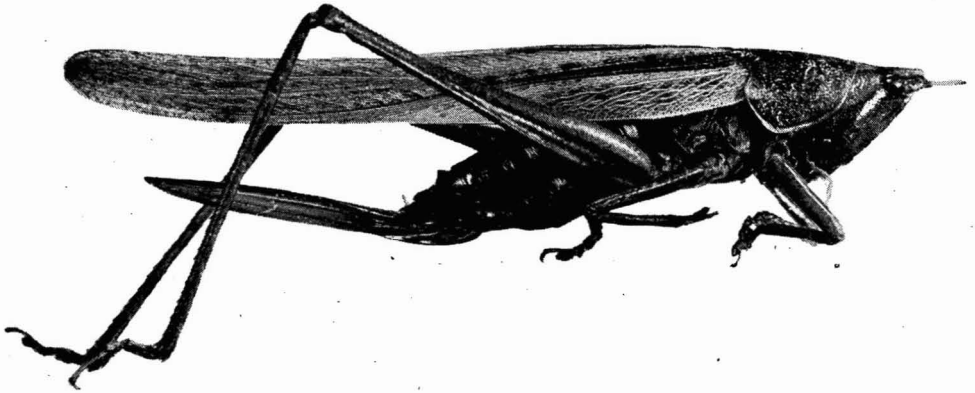


Figure 67—*Conocephaloides remotus* (Walker), a female from Lanai.

buzzing song, perhaps in lush grassy areas at night and tracking down any katydid songsters with the aid of a light.

On the eve of going to press, a fine female example has come to hand. It was collected by T. Miyamoto in a pineapple field on Lanai, January 2, 1941, and it is part of a collection prepared for a University of Hawaii entomology class. This is the first record of the species for about half a century. This example is 50 mm. long (about 2 inches).

#### Genus **BANZA** Walker, 1870

*Microsaga* Saussure, 1888:154.

*Brachymetopa* Redtenbacher, 1891.

This is one of the characteristic endemic genera of the Hawaiian fauna. It probably had its origin in Hawaii from some fully winged ancestral immigrant which was possibly a *Euconocephalus* or a *Euconocephalus*-like insect. The southern and tropical western Pacific areas are richly supplied with such forms which might be ancestral to *Banza*. Hebard (1922:342) said that "*Banza* shows close similarity in general appearance to the genus *Belocephalus*, peculiar to the extreme southeastern United States." However, this similarity is superficial and is not the result of community of origin. I doubt that Hebard wished to convey an opposite impression. *Banza* has much in common with *Euconocephalus* (see the notes under *Conocephaloides*).

All of the species are rather closely allied, and each form is restricted to a single island. The adults are dichromatic, either green or brownish. Some of the species exhibit polychromatism in the nymphal stage. They are nocturnal insects which conceal themselves in foliage during the day and prefer to hide among dead leaves on trees, in dense clusters of foliage, on *Cordyline*, *Freycinetia*, ferns and other plants that give good protection. The eggs are inserted in plant tissues. These

orthopterans are not host-specific and a given species may be found on a number of kinds of plants. The males stridulate at night. They cannot fly, for their wings are atrophied, and the tegmina are greatly reduced; however, they are active jumpers and can often make good their escape even from the most persistent collector. Mynah birds and some of the other introduced birds probably have caused considerable reduction in the numbers of these unusual katydids. At least one *Eupelmus* wasp is a known egg parasite, and Perkins suspected that *Anteris* was also an egg parasite.

It is known that the Hawaiians used to skewer "grasshoppers" on grass stems and roast them over the fire for food many years ago. Could the "grasshoppers" have been *Banza*?

Only Kauai, Oahu and Maui have two species each; each of the other islands has a single species, insofar as we know. The terminalia of the males offer splendid diagnostic morphological characters. Unfortunately, however, there is not a complete set of males and females available to me for study so that a key incorporating the terminalia characters could be prepared. The cerci of the males are greatly modified as clasping organs, and each has two dactyl-like terminal processes. The caudal tergite also displays good specific characters.

Perkins (1899:13) gave a key (in Latin) to the species, and I present here a simple key which will enable the species to be distinguished readily.

#### KEY TO THE SPECIES OF BANZA

1. Kauai species ..... 2  
    Not so ..... 3
- 2(1). Tegmina longer than head and pronotum combined .....  
        ..... *affinis* (Perkins).  
    Tegmina shorter than head and pronotum combined .....  
        ..... *kauaiensis* (Perkins).
- 3(2). Oahu species ..... 4  
    Not so ..... 5
- 4(3). Tegmina obviously broadly rounded at apex; male with ven-  
        tral process of each cercus directed more cephalad than  
        transversely, and the dorsal process, directed transversely,  
        crosses over it when viewed from behind. . . *parvula* (Walker).  
    Tegmina sub-acutely pointed at apex; male with both dorsal  
        and ventral processes of cerci directed more transversely  
        than longitudinally and not crossing one another when  
        viewed from behind. .... *unica* (Perkins).
- 5(3). Molokai species ..... *molokaiensis* (Perkins).  
    Not so ..... 6
- 6(5). Maui species ..... 7  
    Not so ..... 8
- 7(6). Dorsal processes of male cerci long, stout, erect; ovipositor  
        longer than hind femora. .... *brunnea* (Perkins).  
    Dorsal processes of male cerci small, short, not erect; ovi-  
        positor shorter than hind femora. .... *mauiensis* (Perkins).



- 8(6). Lanai species; tegmina only about as long as pronotum...  
 .....**deplanata** (Brunner).  
 Not so; tegmina longer..... 9
- 9(8). Nihoa Island species; tegmina unusually elongate, acuminate .....**nihoa** Hebard.  
 Hawaii species .....10
- 10(9). Tibiae normal, slender.....**nitida nitida** (Brunner).  
 Tibiae unusually stout.....**nitida crassipes** (Perkins).

**Banza affinis** (Perkins).

*Brachymetopa affinis* Perkins, 1899:11.

Endemic. \*Kauai (type locality: in mountains, 3,000 feet, unique; part of Brunner's original series of *B. deplanata*).

**Banza brunnea** (Perkins), new combination.

*Brachymetopa parvula* variety *brunnea* Perkins, 1899:11, pl. 1, fig. 6a.

*Brachymetopa parvula* Perkins, 1899:11, pl. 1, fig. 6; not *parvula* of Walker, 1869. New synonym.

*Brachymetopa brunnea* Perkins, Kirby, 1906:254.

Endemic. Maui (type locality: Lahaina, 3,000 feet).

The green and brown forms are not entitled to separate names, hence the above new synonymy.

**Banza deplanata** (Brunner) (fig. 68).

*Brachymetopa deplanata* Brunner, 1895:894.

Perkins, 1899:12, limits of species; pl. 1, fig. 7; pl. 2, figs. 3, 3a.

Endemic. Lanai (type locality: 2,000 feet).

**Banza kauaiensis** (Perkins) (fig. 68).

*Brachymetopa kauaiensis* Perkins, 1899:10.

Endemic. Kauai (type locality: Makaweli, 2,000 feet).

**Banza mauiensis** (Perkins) (fig. 69).

*Brachymetopa mauiensis* Perkins, 1899:12, pl. 1, fig. 5; pl. 2, figs. 4, 4a.

*Brachymetopa mauiensis* variety *ochracea* Perkins, 1899:12. New synonym.

Endemic. Maui (type locality: Iao Valley, West Maui).

The brown form of this and other species does not deserve a separate name.

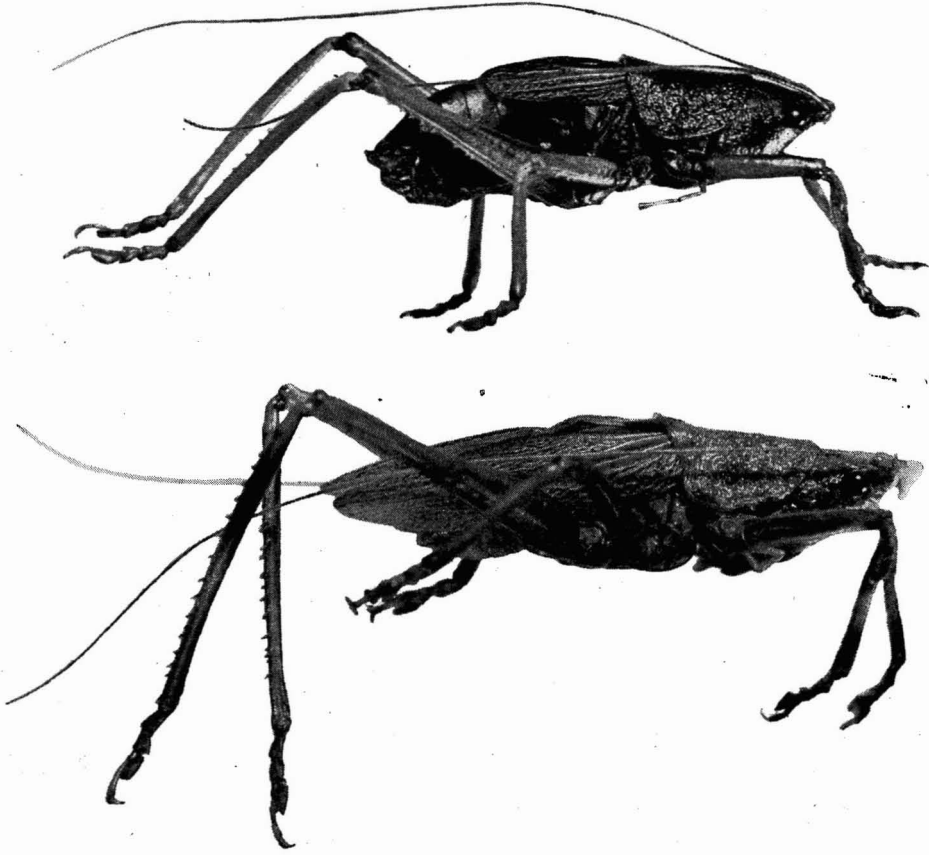


Figure 68—*Banza deplanata* (Brunner), top; *Banza kauaiensis* (Perkins), bottom. Males. (Not to same scale.)

***Banza molokaiensis*** (Perkins) (fig. 69).

*Brachymetopa molokaiensis* Perkins, 1899:12.

Endemic. Molokai (type locality: 3,000–4,000 feet).

***Banza nihoa*** Hebard (fig. 70).

*Banza nihoa* Hebard, 1926:83, fig. 9.

Endemic. Nihoa Island (type locality).

Found in bunch grass. The largest species of *Banza*; it has unusually elongated tegmina. It is noteworthy that the largest species of the genus with the greatest tegminal development should be found on the smallest island now inhabited by the genus.

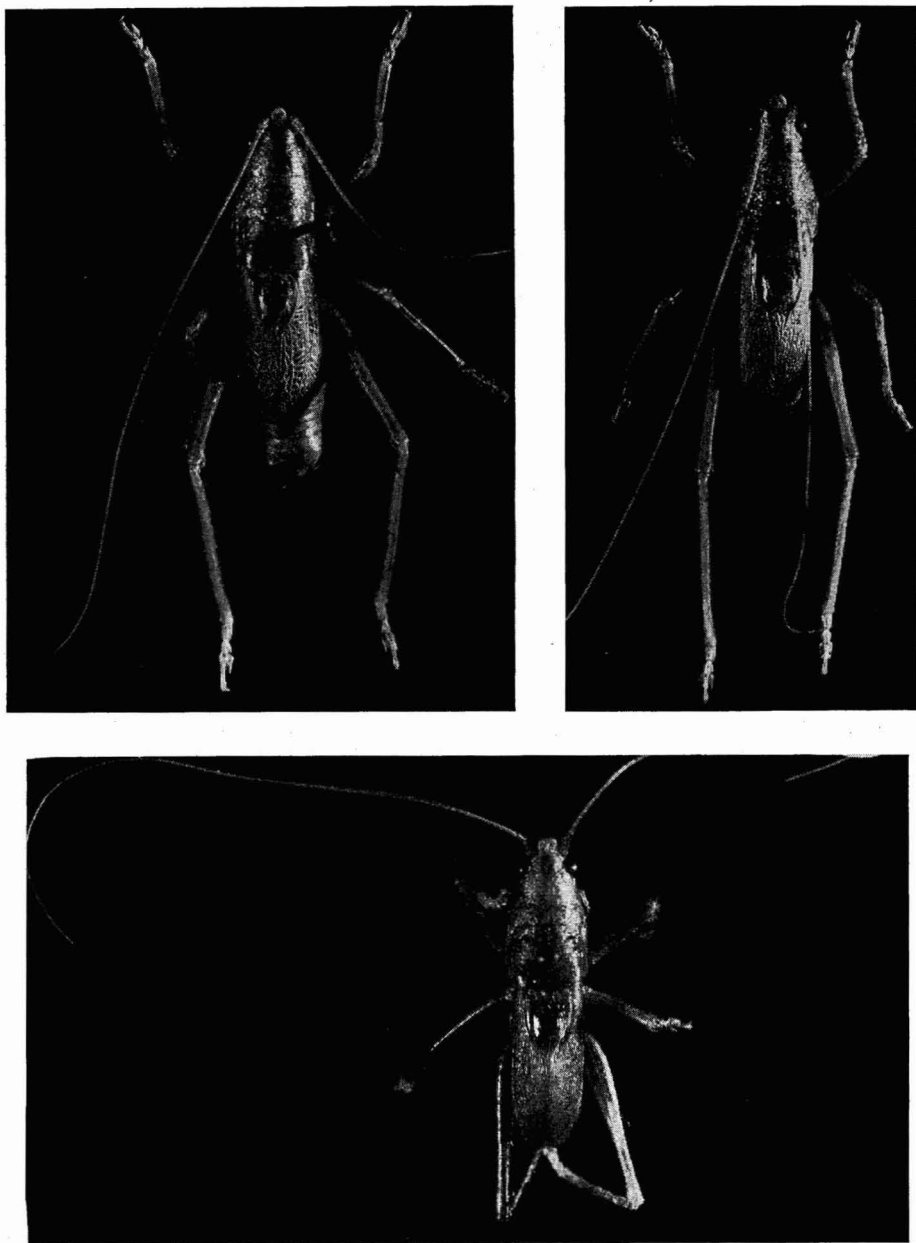


Figure 69—*Banza molokaiensis* (Perkins), left; *Banza mauiensis* (Perkins), right; *Banza unica* (Perkins), bottom. Males. (Not to same scale.)

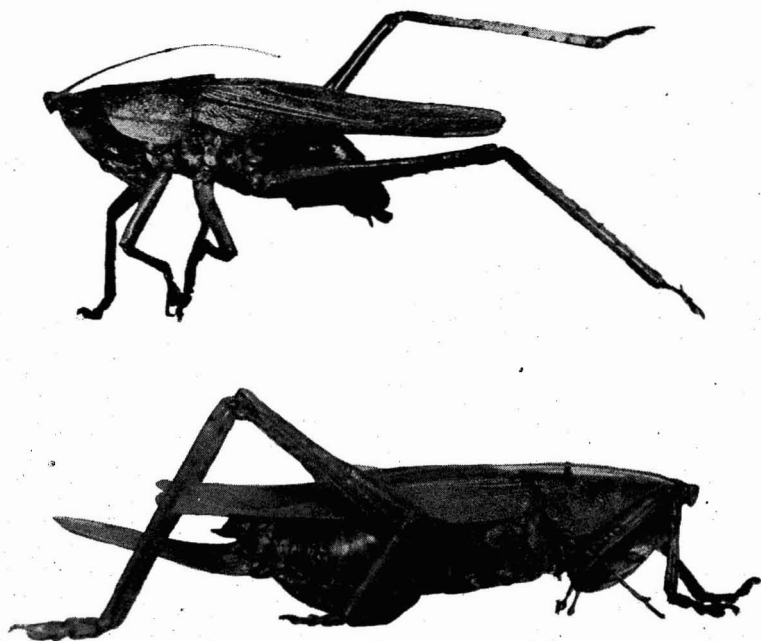


Figure 70—*Banza nihoa* Hebard, male (top), and female. Although this species is found on the smallest island known to support the genus, it is the largest species of the group and has the tegmina more completely developed than those of the other species.

***Banza nitida nitida* (Brunner) (fig. 71).**

*Brachymetopa nitida* Brunner, 1895:894. Perkins, 1899:9, pl. 1, figs. 3, 3a, 3b; pl. 2, figs. 2, 2a.

*Brachymetopa nitida* variety *hiloensis* Perkins, 1899:10 (type locality: above Hilo). New synonym.

*Brachymetopa nitida* variety *punae* Perkins, 1899:10 (type locality: Puna). New synonym.

Endemic. Hawaii (type locality: Kona).

A larger series of specimens assembled since the type series appears to me to show so much intergradation as to make Perkins' varieties untenable.

***Banza nitida crassipes* (Perkins).**

*Brachymetopa nitida* variety *crassipes* Perkins, 1899:10.

Endemic. Hawaii (type locality: Kilauea, 4,000 feet).

I have not seen this form, but it is apparently quite distinct. Hebard, 1922:344, who has examined specimens agrees with Perkins in considering it a separate form. Perhaps it should be called a subspecies, or it may even be a distinct species.

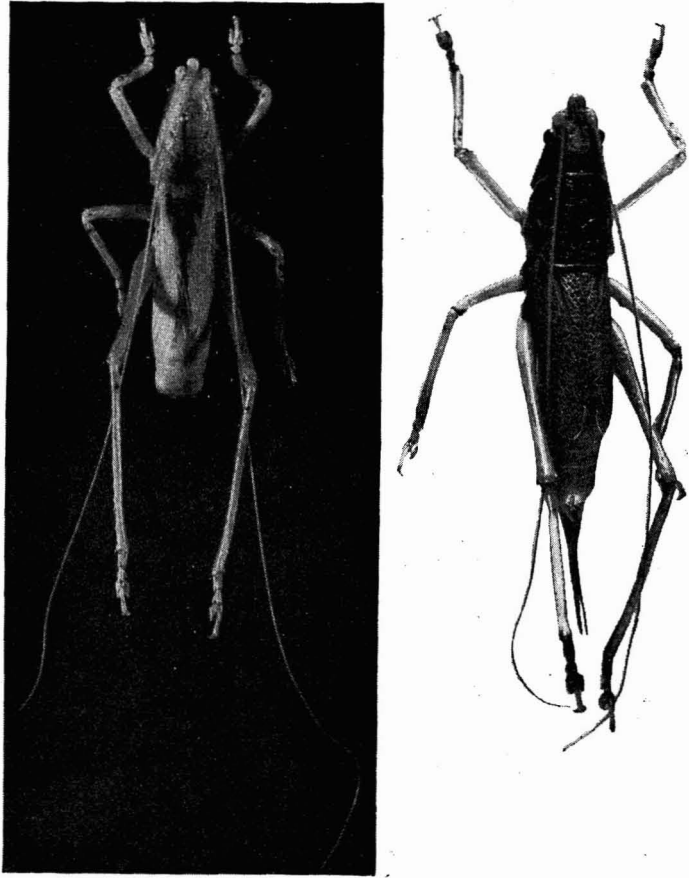


Figure 71—*Banza nitida* (Brunner). Male, left; female, right. (Not to same scale.)

***Banza parvula* (Walker) (fig. 72).**

*Saga parvula* Walker, 1869:293. Genotype of *Banza*.

*Banza nigrifrons* Walker, 1870:477.

*Microsaga parvula* (Walker) Saussure, 1888:155. Genotype of *Microsaga*.

*Conocephalus blackburni* Bormans, 1882:346, 3 figs.

*Brachymetopa blackburni* (Bormans) Redtenbacher, 1891:431.

*Brachymetopa discolor* Redtenbacher, 1891:431, fig. 49. Genotype of *Brachymetopa*.

Perkins, 1899:9, pl. 1, figs. 1, 1a; pl. 2, figs. 1, 1a. 1910:687. 1913, pl. 15, figs. 1-4.

Endemic. Oahu (type locality of all five names).

Parasite: *Eupelmus axestops* Perkins (Hymenoptera: Eupelmidae) in the eggs. Eggs cigar-shaped, 6-7 mm. long.

This species has erroneously been reported from Formosa and the Ryukyu Islands.

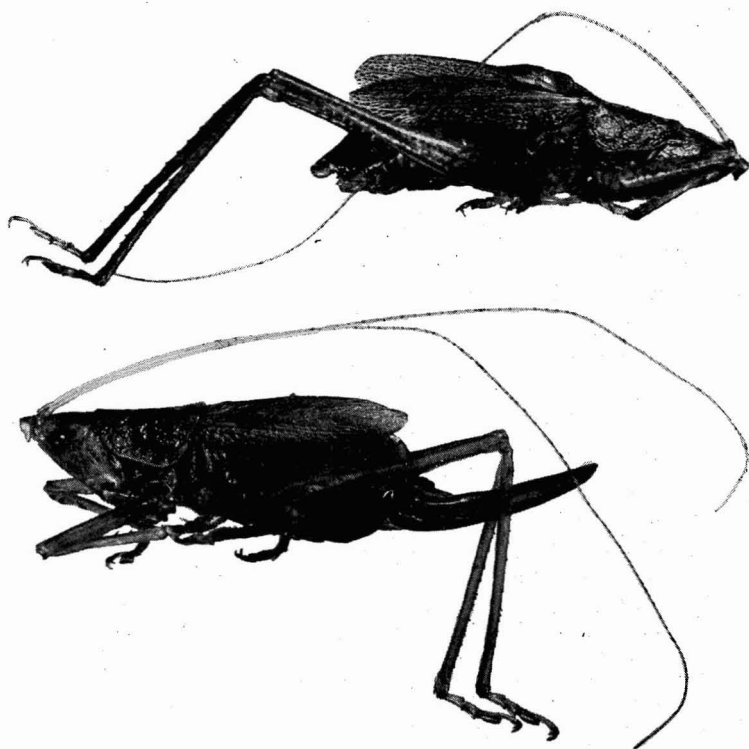


Figure 72—*Banza parvula* (Walker), male (top) and female.

**Banza unica** (Perkins) (fig. 69).

*Brachymetopa unica* Perkins, 1899:10.

Hebard, 1922:344.

Endemic. Oahu (type locality: mountains near Honolulu).

Subfamily CONOCEPHALINAE

Genus **CONOCEPHALUS** Thunberg, 1815

**Conocephalus saltator** (Saussure) (fig. 73).

*Xiphidium saltator* Saussure, 1859:208.

*Xiphidium varipenne* Swezey, 1905:216, pl. 14.

Called *Xiphidium fuscum* Fabricius by error of identification in Hawaiian literature prior to 1905.

Oahu, Molokai, Hawaii, Midway.

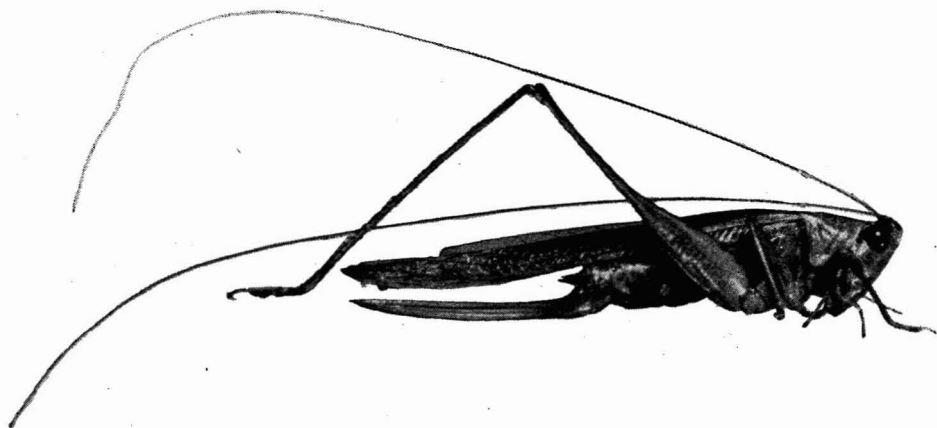


Figure 73—*Conocephalus saltator* (Saussure), female.

Immigrant. Widespread in tropical America. First recorded from Hawaii by Brunner in 1895.

Hosts: *Pseudococcus brevipes*, sugarcane bud moth (*Ereunetis flavistriata* Walsingham) and other caterpillars, dipterous larvae, sugarcane leafhopper (*Perkinsiella saccharicida* Kirkaldy).

Hostplants: blossoms of morning glories, *Canna*, lantana; leaves of young sugarcane, corn, honohono grass, rice, potato, bean blossoms, coffee; rice pollen; ripe guava fruits; occasionally damages pineapples by laying eggs in flowers of young fruit. On occasion this species has caused damage to corn and rice "in the milk," by biting into the heads and eating out the succulent young grain.

Parasites: *Isodontia harrisi* Fernald (Hymenoptera: Sphecidae) on nymphs and adults; *Centrodora xiphidii* (Perkins) (Hymenoptera: Eulophidae) and *Brachistella lutea* (Fullaway) (Hymenoptera: Trichogrammatidae) on eggs.

The stridulation of this species is a rapid chirring which reminds me of the sound of a small electric motor whose brushes squeak as it turns.

Bionomical and morphological studies by Swezey, 1905:212–223. Two to 15 eggs inserted in a group in plant tissue; incubation period from 2 to 5 weeks; 6 molts at 6- to 23-day instars; egg to adult-hood in 2½ to 3½ months; tegmina and wings extremely variable in length, brachypterous or fully developed for flight.

#### Subfamily LISTROSCELINAE

#### Genus **XIPHIDIOPSIS** Redtenbacher, 1891

**Xiphidiopsis lita** Hebard (figs. 74, 75).

*Xiphidiopsis lita* Hebard, 1922:345. Swezey, 1929:279.

Kauai, Oahu, Maui, Hawaii (type locality: Hilo).

Immigrant. First found by Pemberton at Hilo, Hawaii, in 1919; first found on

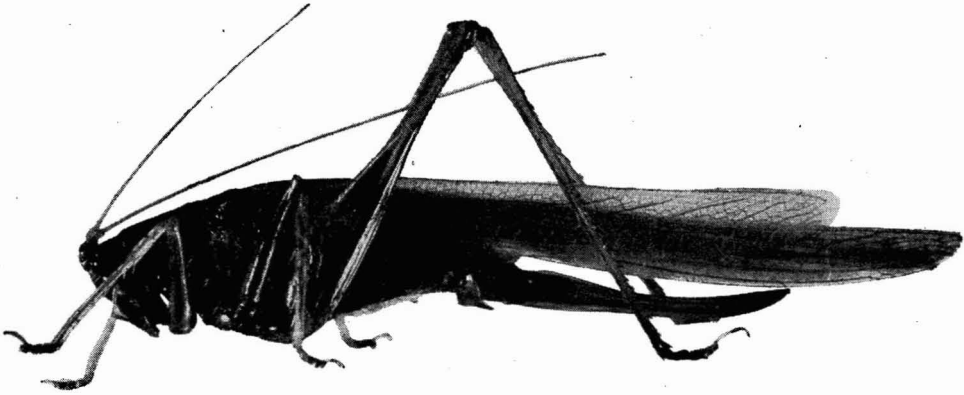


Figure 74—*Xiphidiopsis lita* Hebard, paratype female. No males of this longhorned grasshopper have ever been found. The females reproduce without fertilization.

Oahu at Honolulu by Fullaway, 1923. Origin unknown for many years, but now known from the Society and Marquesas Islands and probably widely distributed in Polynesia.

Hosts: aphids, lepidopterous larvae.

Hostplants: reported occasionally to eat some flower blossoms.

Parthenogenetic; no males known either in Hawaii or elsewhere.

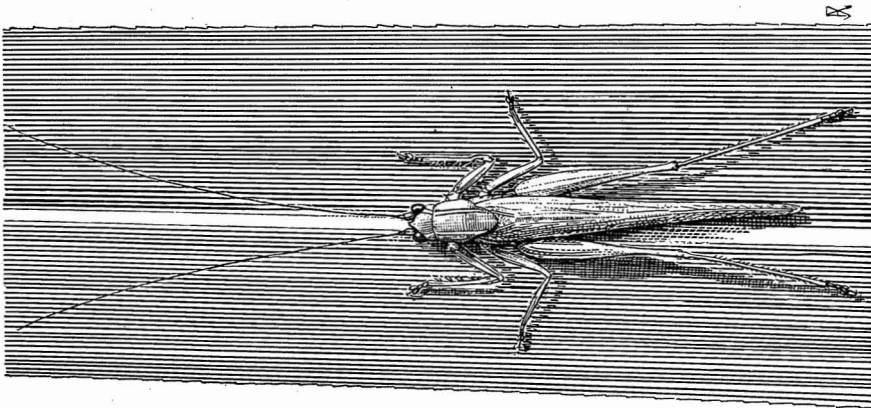


Figure 75—*Xiphidiopsis lita* Hebard, resting in a characteristic position on a sugarcane leaf. (From Williams' original drawing, 1931.)

## Family GRYLLIDAE Saussure, 1894

### Crickets

Leaping insects; head exposed, prominent in most species, prognathus in some genera; face vertical or almost so in most groups; antennae variable, but longer than body in most species (shorter than head and prothorax only in *Gryllotalpa*), setaceous, many-segmented, inserted between eyes or between and below eyes;



compound eyes not very large, but conspicuous; ocelli present or absent; mandibles large, prominent, dentate; maxillary palpi five-segmented; labial palpi three-segmented; pronotum large, shield-like or saddle-like; wings variable, present or absent, fully developed or brachypterous; tegmina, when fully developed, longitudinally angulate and bent downward along sides of body and flat dorsally, modified into strongly developed stridulating organs in males; abdomen 10-segmented; with nine complete tergites visible; males with nine complete ventrites, females with seven; ovipositor variable, wanting in *Gryllotalpa*, but exerted, long and well-developed in most forms, composed of four slender sclerites; cerci elongate, not segmented; hind legs with femora and tibiae strongly developed for leaping (excepting *Gryllotalpa*); fore tibiae bearing the tympanal organs when they are present; tarsi three-segmented, first segment elongate, second shortened, pulvilli absent in most species; tarsal claws divaricate or divergent, without empodia; oviparous, eggs deposited in soil, either singly or in groups, or in plant tissues; nocturnal insects of herbivorous or omnivorous habit.

There have been 42 crickets recorded from Hawaii. The family reaches its greatest diversity in the tropics; and there are over 1,000 species described from the world. There are both immigrant and endemic species in the Hawaiian fauna. In the endemic section there have been 33 species described in six genera, five of which are endemic. The eight immigrant species are included in six genera. The group is the most diversified family of the Hawaiian Orthoptera. The smallest members of the order belong here (*Myrmecophila*).

The crickets are the best known of insect songsters and are rivaled, but not equaled, only by the katydids. In some places in the world crickets are kept in cages so that their captors may enjoy their songs and chirpings. Stridulation is accomplished by the male which raises his tegmina at an angle above the abdomen and rubs them across one another. A file-like area on one tegmen rubs across a specialized, sclerotized area on the other tegmen, thus vibrating a drum-like membrane and causing the characteristic sound. Unlike most Orthoptera, the right tegmen of the male crickets normally overlaps the left, instead of vice versa. The chirping of some of our endemic forest crickets has been accredited to arboreal Mollusca, which the Hawaiians thought were singing land snails.

Crickets may be found in Hawaii from burrows in the soil to tree tops, from seashore to mountain top; the members of one genus are myrmecophiles.

#### KEY TO THE CRICKET SUBFAMILIES FOUND IN HAWAII

1. Fore legs expanded, greatly modified for burrowing, their tibiae and first tarsal segments armed with great, blade-like teeth ..... *Gryllotalpinae*.  
Fore legs slender, not fitted for burrowing..... 2
- 2(1). Tarsi with the second segment laterally compressed, usually small, obscure and more or less hidden in apex of tibia.... 3

- Tarsi with the second segment exposed and distinct, dorso-ventrally depressed in most species (laterally compressed in some endemic Eneopterinae, but then fully exposed and conspicuous) ..... 5
- 3(2). Small, apterous, myrmecophilous crickets not more than 5 mm. long; head partly retracted into prothorax; eyes small, partly covered by pronotum; hind femora abnormally broad and expanded, ovate, less than twice as long as broad ..... **Myrmecophilinae.**
- Larger insects; head not retracted, eyes fully exposed and separated from pronotum; hind femora elongate, more than twice as long as broad..... 4
- 4(3). Body squamose; hind tibiae with some apical spines and spurs and at most a row of small tooth-like or seta-like spines along each dorsal margin, but without large dorsal spines above apex .....part of **Mogoplistinae.**
- Body not squamose; dorsa of hind tibiae armed on each side with a row of numerous large, strong, long, conspicuous spurs ..... **Gryllinae.**
- 5(2). Hind tibiae with about six long, dorsal, dactyl-like spurs above apex and without teeth-like spines; ovipositor blade-like, strongly compressed, conspicuously arcuate, scimitar-like ..... **Trigonidiinae.**
- Hind tibiae with a row of many short, tooth-like dorsal spines along each margin, but without any long spurs above apical group; ovipositor subcylindrical, almost straight or gently arcuate, but not scimitar-like..... 6
- 6(5). Body conspicuously squamose; hind tibiae somewhat more than one-half as long as femora, but not almost as long .....part of **Mogoplistinae.**
- Body not squamose; hind tibiae as long or about as long as hind femora ..... **Eneopterinae.**

Subfamily GRYLLOTALPINAE

Genus **GRYLLOTALPA** Latreille, 1802

**Gryllotalpa africana** Palisot de Beauvois (fig. 76).

*Gryllotalpa africana* Palisot de Beauvois, 1805:229, pl. Orthoptera IIc, fig. 6.  
Williams, 1931:70, pl. 6. Tindale, 1928:11-16, fig. 4.

The African mole cricket.  
Kauai, Oahu, Maui.

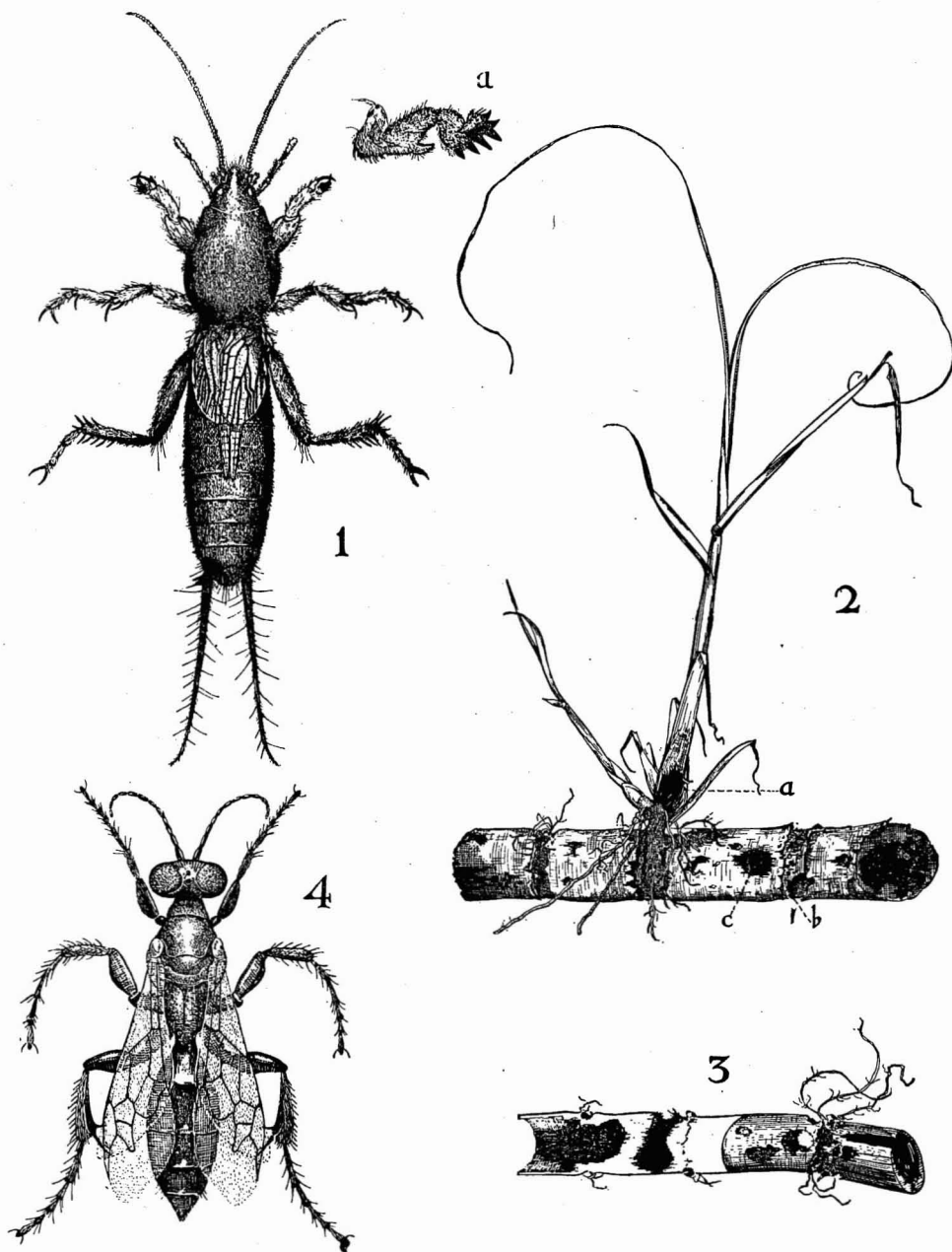


Figure 76—*Gryllotalpa africana* Palisot de Beauvois. 1, Adult; 1a, fore leg to show the modifications for digging. 2, A piece of injured "plant cane," showing at a, a young shoot which has been eaten into and killed and a new shoot starting out at the left; b, a destroyed "eye," and a hole eaten through the rind at c. 3, A much-eaten piece of cane partially sectioned to show internal injury. 4, *Larra luzonensis* Rohwer, a Philippine wasp introduced to prey on the cricket. (After Swezey, 1923.)

Immigrant. Widespread. Africa, China, Philippines, Formosa, Japan, Java, Australia, New Zealand. Recorded by Koebele as common on Oahu in 1896 (1896:594).

Hosts: earthworms, scarab larvae (*Adoretus*, *Aphodius*).

Parasite: *Larra luzonensis* Rohwer (Hymenoptera: Larridae), on nymphs and adults.

Predator: mongoose.

The mole cricket may burrow down three or four feet in the soil. Its burrows cause leaks in irrigation canal walls and taro-field dikes; it eats the eyes and young shoots of seed sugarcane in some low-lying, damp or swampy sugarcane fields, and it has caused up to 75 percent killing of seed cane in some localities in past years. However, little damage is now reported in sugarcane fields. "The eggs are laid in a group in a specially prepared brood chamber and the young require some months to become full grown" (Williams, 1931:71). Tindale (1928) gives a good account of the species.

Wisecup (1943), working on the mole crickets of the southeastern United States (different species from ours), where an estimated injury of two million dollars is caused annually, says that "Mole crickets damage crops by feeding on the roots, root stems, tubers, or fruits of the plants and also by burrowing in the upper inch or two of the soil about the roots, causing affected plants to dry out or uprooting them. Sprouting seedlings or transplants of many crops are specially subject to injury through being fed upon or uprooted. Since one mole cricket in burrowing can cover several yards of territory in a single night, the damage done by only a few specimens per square yard sometimes completely destroys a seed bed in a few nights." He has found the following poisoned bait effective: 100 pounds of dry wheat bran and 8 pounds sodium fluosilicate moistened with 3 to 5 gallons of water and thoroughly mixed. This is strewn evenly over infested fields at about 20 pounds of dry mixture per acre and repeated once or twice at 10-day intervals.

#### Subfamily GRYLLINAE

#### KEY TO THE GENERA FOUND IN HAWAII

1. Tegmina short, leaving about one-half or more than one-half of abdomen exposed; narrowest part of interantennal area of face hardly if any broader than greatest transverse chord of an antennal fossa ..... **Gryllodes** Saussure.
2. Tegmina elongate, concealing almost all of abdomen; narrowest part of interantennal area of face obviously broader than greatest transverse chord of an antennal fossa, about one and one-half or up to twice as broad..... **Acheta** (Linnaeus).

Genus **GRYLLODES** Saussure, 1874

**Grylloides sigillatus** (Walker) (fig. 77).

*Gryllus sigillatus* Walker, 1869:46.

*Gryllus pustulipes* Walker, 1869:51.

*Gryllus poeyi* Saussure, 1874:420, pl. 7, fig. 8.

Kauai, Oahu, Molokai, Maui, Kahoolawe, Hawaii.

Immigrant. Mauritius, India, Australia, North, Central and South America.  
First recorded from Hawaii by Brunner in 1895.

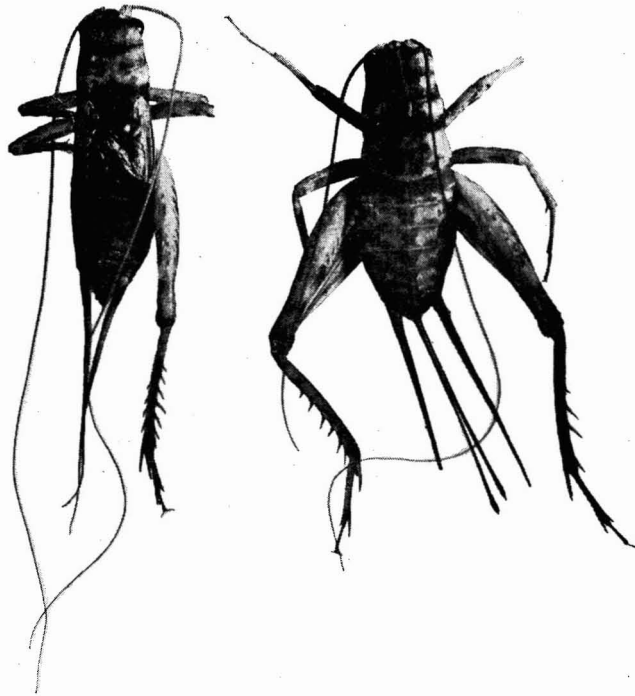


Figure 77—*Grylloides sigillatus* (Walker). Male, left; female, right.

Genus **ACHETA** (Linnaeus)

*Gryllus* (*Acheta*) Linnaeus, 1758:428.

*Gryllulus* Uvarov, 1935:320.

For discussion of synonymy, see Roberts, 1941:33-34.

## KEY TO THE SPECIES FOUND IN HAWAII

1. Length of body excluding terminalia 15–20 mm. or more; head normally without a distinct pale fascia between posterior ocelli, but if a narrow pale line is present it is broadly  $\wedge$ -shaped; crown with several rather obscure pale vittae, but not tending to coalesce so as to make entire base of head appear pale; shortest distance between inner margins of antennal fossae twice as broad as first antennal segment. .... *oceanica* (LeGuillou).
2. Length of body excluding terminalia less than 15 mm.; head with a conspicuous, slightly arcuate, moderately broad, pale fascia extending from eye to eye across posterior ocelli; crown usually predominantly pale, tending to have a broad, pale band entirely around base of head, this area usually with short pale vittae; shortest distance between inner margins of antennal fossae distinctly less than twice as broad as first antennal segment. .... *conspersa* (Schaum).

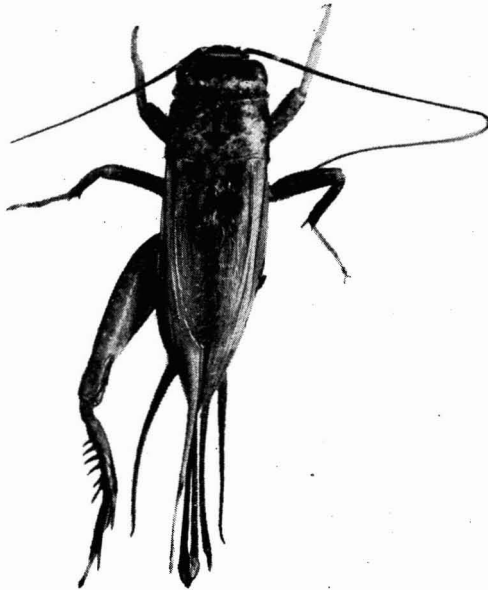


Figure 78—*Acheta conspersa* (Schaum), female.

***Acheta conspersa*** (Schaum) (fig. 78).

*Gryllus conspersus* Schaum, 1862:117.

Kauai, Oahu, Hawaii.

Immigrant. Africa, India, Japan, Formosa, Ryukyu Islands, Indo-Pacific. Collected by Perkins, but not recorded by name until Hebard listed it in 1922 (p. 350).

***Acheta oceanica*** (LeGuillou) (fig. 79).

*Gryllus oceanicus* LeGuillou, 1841:293.

*Gryllus innotabilis* Walker, 1869:47.

Lyon, 1914:180, figs. 2, 3, adult and injury to pineapple. Swezey, 1918:9, figure showing damage to sugarcane.

The oceanic field cricket.

Kauai, Oahu, Molokai, Maui, Lanai, Hawaii.

Immigrant. Widespread in Oceania from the Malay Peninsula eastward, including Penang, Borneo, New Hebrides, Solomons, Fiji, Samoa, Tonga, Society Islands, Marquesas (type locality: Nukuhiva), Easter Island; also recorded from Japan. It was widespread in the Hawaiian Islands when first recorded by Bormans in 1882.

Food: It eats most any vegetable matter available. It is recorded to eat occasionally into pineapple fruits, damaging the fruit and allowing entrance of fungi and bacteria and to gnaw the leaves; also damages sugarcane by eating holes in canes in contact with ground litter. Swezey (1918) reported 10 percent of such prostrate canes damaged in some localities. For control, Lyon (1914) suggested using poison baits made with molasses; such baits are readily eaten by the crickets.

Parasite: *Notogonidea subtessellata* (F. Smith) (Hymenoptera: Larridae), on nymphs and adults.

Predator: The mongoose eats quantities of these crickets.



Figure 79—*Achaeta oceanica* (LeGuillou), the oceanic field cricket. Male, left; female, right.

Bionomical studies by Swezey (1918:9). Eggs deposited singly in soil,  $2.3 \times 0.5$  mm., whitish; incubation period about three weeks; nymphal stage between four and five months; adults live two months or more. The steady rhythmic beat of this field cricket is commonly heard on warm summer nights. I have seen the males stand with their legs widely spread and their tegmina uplifted a bit and rapidly vibrating as they chirp. Now and again two males will fight a speedy, lusty battle and then each retire to continue his throbbing chirping.

Subfamily MYRMECOPHILINAE

Genus MYRMECOPHILA Latreille, 1829

*Myrmecophilus* Berthold, 1827.

These tiny crickets live in ants' nests.

KEY TO THE SPECIES FOUND IN HAWAII

1. Mesonotum obviously paler than pronotum; dorsal, inner margin of hind tibia with three spines above apical spurs, each progressively longer, counted toward apex of tibia; outer dorsal margin with a single spine similar to second spine in inner row but situated well distad of it. . . . . **americana** Saussure.
2. Mesonotum concolorous with pronotum; dorsal inner margin of hind tibia with four spines above the long apical spurs, alternating in length, a short, a long, a short and a long spine counted toward apex of tibia; outer dorsal margin with a single spine above apical spur about as long as second spine in inner row and situated slightly distad of it. . . . . **quadrispina** Perkins.



Figure 80—*Myrmecophila quadrispina* Perkins. A tiny cricket which lives in ant nests



**Myrmecophila americana** Saussure.

*Myrmecophila americana* Saussure, 1877:461.

Oahu.

Immigrant. South America, India. First recorded in Hawaii by Hebard (1925:302) from specimens collected in 1924.

Host ant: *Paratrechina longicornis* (Latreille).

**Myrmecophila quadrispina** Perkins (fig. 80).

*Myrmecophila quadrispina* Perkins, 1899:14, pl. 2, fig. 7. Hebard, 1922:351, expanded redescription.

Kauai, Oahu (type locality: Honolulu).

Immigrant. Described from Hawaii, but now known from Samoa and also recorded from Hongkong. Perkins (1913:ccxvii) mentions intercepting it from shipments of plants in quarantine at Honolulu. Hebard (1933:65) considers that the extra-Hawaiian records need verification.

Host ants: *Pheidole megacephala* (Fabricius), *Solenopsis geminata rufa* (Jerdon), *Paratrechina* species.

## Subfamily MOGOPLISTINAE

## KEY TO THE GENERA AND SPECIES FOUND IN HAWAII

1. Length greater than 10 mm.; when viewed from side, the strongly protuberant front of head is obviously discontinuous in longitudinal outline with top of head; hind tibiae with a well-defined row of conspicuous, dark-tipped teeth along each dorsal margin; first hind tarsal segment about one-third as long as a hind tibia, with a row of conspicuous, dark-tipped teeth along each dorsal margin; second tarsal segment conspicuous ..... **Cycloptilum bimaculatum** (Shiraki).
2. Length less than 8 mm.; front of head forming an almost continuous longitudinal outline with top of head; hind tibiae without dorsal marginal teeth, but with slender, inconspicuous, seta-like spines only; first hind tarsal segment more than one-half as long as a hind tibia, with dorsal seta-like spines but no teeth; second tarsal segment inconspicuous ..... **Cycloptiloides americanus** (Saussure).

Genus **CYCLOPTILUM** Scudder, 1868

*Liphoplus* Saussure, 1876:77.

**Cycloptilum bimaculatum** (Shiraki) (fig. 81).

*Liphoplus bimaculatus* Shiraki, *Insecta Matsumurana* 4:192, fig. 5, 1930.

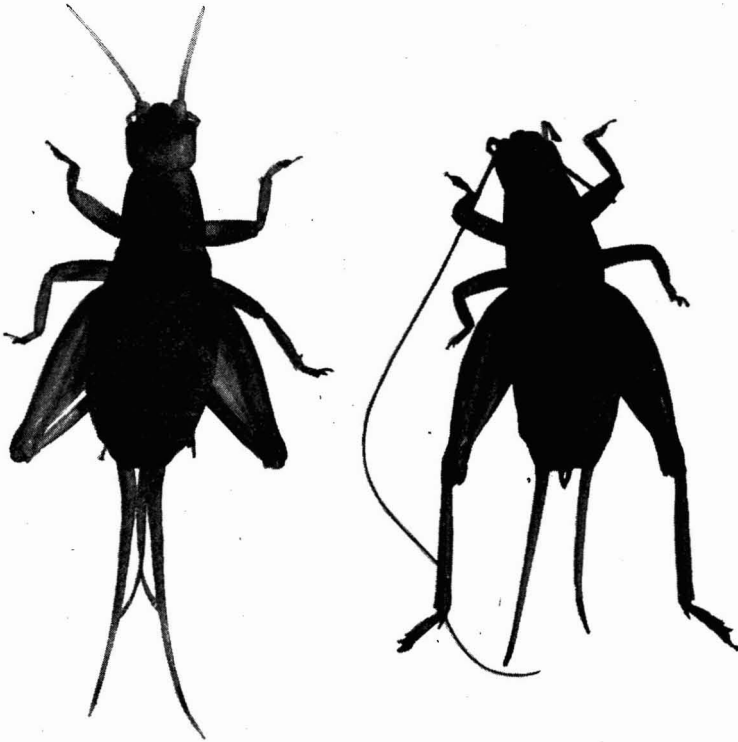


Figure 81—*Cycloptilum bimaculatum* (Shiraki). Male, right; female, left.

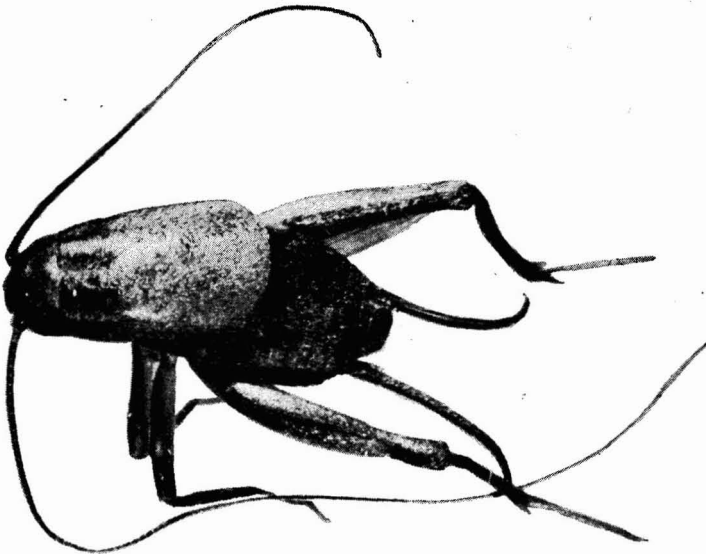


Figure 82—*Cycloptiloides americanus* (Saussure).

Kauai, Oahu.

Immigrant. Described from Formosa. First recorded by Pemberton in 1940 (1941) from specimens found in a house in Honolulu.

### Genus **CYCLOPTILOIDES** Sjöstedt, 1909

*Glaphyropus* Rehn and Hebard, 1912.

**Cycloptiloides americanus** (Saussure) (fig. 82).

*Cycloptilum americanus* Saussure, 1874:426, pl. 8, figs. 41, 42.

Misnamed *Paranemobdus schauinslandi* Alfken in early Hawaiian literature.

Kauai, Oahu, Molokai, Hawaii.

Immigrant. First recorded by Perkins from Honolulu (1910:688). Central America.

Habit: in rubbish; in houses, where it is most often found in sinks, bathrooms, or other places where water or moist conditions are available. It becomes more abundant in damp weather. Stridulation is accomplished by an up-and-down movement of the prothorax.

### Subfamily TRIGONIDIINAE

#### KEY TO THE GENERA OF TRIGONIDIINAE FOUND IN HAWAII

1. Wings fully developed for flight, much longer than abdomen .....part of **Metioche** Stål.  
 Wings not developed for flight, at most only slightly surpassing abdomen ..... 2
2. Venation of both tegmina of male essentially similar; tegmina of female with only about four complete longitudinal, dorsal veins between the vein at top of lateral declivitous part and inner edge, and these not connected by numerous cross-veins .....part of **Metioche** Stål.  
 Venation of tegmina of male conspicuously different, right tegmen broad and flat above, with a well-developed transverse "vena-stridulans" and complete "mirror" at base; tegmina of female with more than four veins, usually about seven, veins close together and connected by many cross-veins or pseudo-cross-veins from base to apex.....**Paratrigonidium** Brunner.

### Genus **PARATRIGONIDIUM** Brunner, 1893

This genus constitutes the second complex of endemic species of Hawaiian Orthoptera, and, together with the species of *Banza* and the Prognathogryllini which follow, it makes up a characteristic element in the native insect fauna of Hawaii. *Paratrigonidium* was described from Burma and Java and now is known also from the Philippines, Formosa and Japan. It closely resembles such allied extra-Hawaiian genera as *Metioche* and *Anaxipha*, which are found widespread in the islands to the south and southwest. Dr. Chopard tells me that he feels that

our species are "very different from the type species" of the genus. The matter needs careful study. The Trigonidiinae is a systematically difficult assemblage.

All our species are flightless. The wings and tegmina develop equally well up to the last molt, but at that ecdysis the hind wings are lost. However, the loss of the powers of flight is partially counteracted by the extraordinarily developed powers of leaping. Some of the species can jump several feet at a time and are most difficult to capture.

One of our species (*P. pacificum*) is largely terrestrial, but the remainder of the forms are mostly arboreal in habit and are to be found on ferns, shrubs and trees. Some species appear to be host-specific and are confined to one kind of fern, shrub or tree. In fact, one species (*P. atroferrugineum*) is said by Perkins to be so host-specific as to be attached to only one variety of the multiform tree *Metrosideros polymorpha*. Several species hide beneath the bark of trees. Most of the species are nocturnal, but some are to be found active during the day in the gloom of canyons and forest. Some species chirp during the day as well as being more active at night. Perkins (1899:15) said, "There is a considerable difference between the songs of some of the species, and in some cases the sound can be heard at a great distance." It is the chirping of these crickets that gave rise to the Hawaiian myth of the singing land snails.

The young of the foliage-frequenting species are generally green, whereas those of the terrestrial or bark-frequenting species are brownish.

These crickets are much sought by some of the endemic Hawaiian birds. Perkins records one drepaniid (*Viridonia sagittirostris*) as feeding extensively on the *Freycinetia*-frequenting *Paratrigonidium freycinetiae*.

I have no record of any insect parasites of the group, but Perkins (1913:ccxviii) and Hebard (1922:358) record *Gordius* roundworm parasites, and I have also seen them. I have seen the native nabid bug, *Nabis lusciosus* White, feeding on the nymphs of the terrestrial *P. pacificum* Scudder on Oahu.

A note sent by Dr. Perkins with a box of specimens of *Paratrigonidium* states that "The whole *second* set—the first of course went to the British Mus.—was given to Brunner V.W., on account of the help given at the start. I myself did not have any of the collection described in F. H. [*Fauna Hawaiiensis*] except the left over specimens of the huge series of *P. pacificum*."

It is unfortunate that the beauty of these crickets is mostly lost after death. A collection of them becomes a rather drab lot because of fading or darkening of their colors, but in life many are distinctly colored and are attractive insects. Degreasing by soaking in ether will make specimens more attractive and will aid in making certain markings more evident.

The species are not well-known, and I feel that there is a certain amount of confusion regarding them. The preparation of a key to the species is not an easy task, and I am far from satisfied with the present attempt. Certain of the species have been represented by only one or a few specimens in the collections available for study. I have not seen *robustum* from Kauai and it is not included in the following key.

## KEY TO THE HAWAIIAN PARATRIGONIDIUM

(Excepting *robustum*)

1. Lateral field (declivitous part) of male tegmina with eight veins basad, as in figure 83; male subgenital plate elongate, subconical, concealing the genital valves which do not bear long arms from their external sides; ovipositor with the "transverse suture" nearer base than apex (measured along dorsal edge); a terrestrial species on all main islands ..... **pacificum** Scudder.

Not such species, the lateral tegminal field of male usually with only six veins, rarely with seven; male subgenital plate, even if shaped somewhat as above, not concealing the long processes ("claspers") of the genital valves; ovipositor with the "transverse suture" nearer apex than base ..... 2



Figure 83—Sketches of lateral tegminal fields of males of *Paratrigonidium attenuatum* Perkins, left, and *P. pacificum* Scudder, right, to show differences in venation. The venation is variable within these species.

- 2(1). Kauai species ..... 3  
Not so ..... 5
- 3(2). A comparatively pale species, predominantly testaceous; subgenital plate (terminal ventrite) of male deeply concavely emarginate at apex; speculum of male tegmen "very narrow" ..... **attenuatum** Perkins.  
Brownish, not predominantly testaceous species; apex of subgenital plate of male not deeply concave ..... 4
- 4(3). Male subgenital plate with a distinct, although small, median, caudal protuberance ..... **crepitans** Perkins.  
Male subgenital plate nearly evenly, broadly, shallowly concave behind, the median part of hind margin not produced into a process ..... **varians** Perkins.
- 5(2). Oahu species ..... 6  
Not so ..... 10
- 6(5). An almost entirely pale species (excepting male abdomen) tinged with pink or reddish (largely lost after drying), legs nearly or quite immaculate; tegmina of male without a dark macula behind vena stridulans; male subgenital plate nearly subtruncate apically with the middle slightly produced ..... **subroseum** Perkins.  
Without such a combination of characters ..... 7
- 7(6). Right male tegmen without a dark macula behind vena stridulans; genital "claspers" with teeth reduced, the subapical one obsolete, the terminal one minute ..... 8

- Right male tegmen with area behind vena stridulans dark;  
genital "claspers" each with two well-developed teeth,  
although the subapical one may be slender..... 9
- 8(7). Fore and mid femora entirely dark, hind femora dark  
along dorsal edges and contrasting with paler color of  
head, pronotum and tegmina; subgenital plate deeply  
concave behind; cerci more than 3 mm. long.....  
.....**saltator** Perkins.  
Femora not contrasting in color with head, pronotum and  
tegmina; subgenital plate produced at middle; cerci only  
about 2.5 mm. long .....**exiguum** Perkins.
- 9(7). Subgenital plate of male produced at middle of hind  
margin .....**debile** Perkins.  
Subgenital plate of male nearly evenly, broadly, shallowly  
concave behind, not produced at middle....**varians** Perkins.
- 10(5). Molokai species .....11  
Not so .....13
- 11(10). Femora black with red apices; tibiae reddish; male teg-  
mina with entire disk dark with edges and lateral fields  
orange and reddish; a striking species.....  
.....**atroferrugineum** Brunner.  
Not such species; predominantly brown, maculate.....12
- 12(11). Head between antennae black; clypeus black.....  
.....**molokaiense** Perkins.  
Head and clypeus brown and testaceous, maculate.....  
.....**varians** Perkins.
- 13(10). Maui species .....14  
Not so .....15
- 14(13). Head, base of antennae, femora and hind tibiae reddish  
or pinkish .....**roseum** Perkins.  
Brownish and testaceous species.....**varians** Perkins.
- 15(13). Lanai species .....**varians** Perkins.  
Hawaii species .....16
- 16(15). Right male tegmen with a number of dark marks similar  
in color to the dark color in the vena stridulans area but  
scattered over all; dark marks on legs outstanding, tibiae  
conspicuously annulate; pale greenish in life.....  
.....**viridescens** Perkins.  
Not such species, dark color on right male tegmen confined  
to neighborhood of vena stridulans or entire tegmen  
infusate .....17
- 17(16). Largest species in Hawaii, about 8.5 to 9.5 mm. in length  
from front of head to apex of tegmina; tegmina more  
than 5 mm. long.....**grande** Perkins.  
Smaller species, less than 7.5 mm. in length, with tegmina  
not over 5 mm. long.....18
- 18(17). Fore and mid femora entirely dark and contrasting with  
the pale, annulate tibiae.....**freycinetiae** Perkins.  
Fore and mid femora not dark colored.....19

- 19(18). Legs indistinctly maculate, if at all spotted; hind tibiae almost entirely pale ..... **filicum** Perkins.  
 Legs distinctly maculate and/or annulate; hind tibiae mostly dark ..... **varians** Perkins.

**Paratrigonidium atroferrugineum** Brunner.

*Paratrigonidium atroferrugineum* Brunner, 1895:895. Perkins, 1899:17, pl. 1, fig. 10.

Endemic. Molokai (type locality: 4,000 feet).

Hostplant: *Metrosideros*.

Hebard (1922:360) stated that "This, the handsomest known species of the genus, ranks among the most distinctively and beautifully colored Gryllidae of Earth."

The nymphs are green.

**Paratrigonidium attenuatum** Perkins (figs. 83, 84).

*Paratrigonidium attenuatum* Perkins, 1899:20, pl. 1, fig. 13; pl. 2, fig. 5.

*Paratrigonidium attenuatum* variety *major* Perkins, 1899:20, new synonym.

*Paratrigonidium attenuatum* variety *minor* Perkins, 1899:20, pl. 2, fig. 5, new synonym.

Endemic. Kauai (type locality: 4,000 feet).

Habit: under bark of large trees.

No mention of this species was made either by Kirby (1906) or Hebard (1922).

**Paratrigonidium crepitans** Perkins.

*Paratrigonidium crepitans* Perkins, 1899:19. Hebard, 1922:359.

Endemic. Kauai (type locality: 4,000 feet).

Habit: in piles of dead wood and in low shrubbery.

**Paratrigonidium debile** Perkins.

*Paratrigonidium debile* Perkins, 1899:21. Hebard, 1922:356.

Endemic. Oahu (type locality: mountains above 2,000 feet).

**Paratrigonidium exiguum** Perkins.

*Paratrigonidium exiguum* Perkins, 1899:21.

Endemic. Oahu (type locality: Waianae Mountains, 3,000 feet).

Habit: arboreal.

**Paratrigonidium filicum** Perkins.

*Paratrigonidium filicum* Perkins, 1899:17, pl. 2, fig. 6. Hebard, 1922:356, pl. 27, fig. 2.

Endemic. Hawaii (type locality: Oloo, 2,000 feet).

Hostplant: a "tall fern."

The nymphs are green.

**Paratrigonidium freycinetiae** Perkins (fig. 84).

*Paratrigonidium freycinetiae* Perkins, 1899:16.

Endemic. Hawaii (type locality: Oloo, 2,000 feet).

Hostplant: *Freycinetia*.

Predator: the drepaniid bird *Viridonia sagittirostris*.

**Paratrigonidium grande** Perkins (fig. 84).

*Paratrigonidium grande* Perkins, 1899:19, pl. 1, fig. 12. Hebard, 1922:355, pl. 27, fig. 1.

*Paratrigonidium "gracile"* Perkins, Hebard, 1926:301 (name cited in error).

Endemic. Hawaii (type series from Puna, Kau and Kona).

Habit: under bark of trees.

The nymphs are brownish.

**Paratrigonidium molokaiense** Perkins (fig. 84).

*Paratrigonidium molokaiense* Perkins, 1899:20.

Endemic. Molokai (type locality: 3,000 feet).

Habit: frequents low shrubbery.

**Paratrigonidium pacificum** Scudder (figs. 83, 84).

*Paratrigonidium pacificum* Scudder, 1868:139. Brunner, 1895:895. Perkins, 1899:22, pl. 2, fig. 6a. Hebard, 1922:361, pl. 27, fig. 6.

Endemic. Kauai, Oahu, Molokai, Lanai, Maui, Hawaii (type locality: "Hawaiian Islands," unique female; the first described Hawaiian species).

Predator: *Nabis lusciosus* White (Heteroptera: Nabidae).

Habit: more terrestrial than the other species.

This is a common ground form, and the forest rings with its chirping wherever it is found. It may be collected in large numbers if a paper or similar article is laid out on a trail or over the grass in its habitat, for the crickets will congregate beneath it. A partially opened paper sack will lure them inside where they can be easily secured.



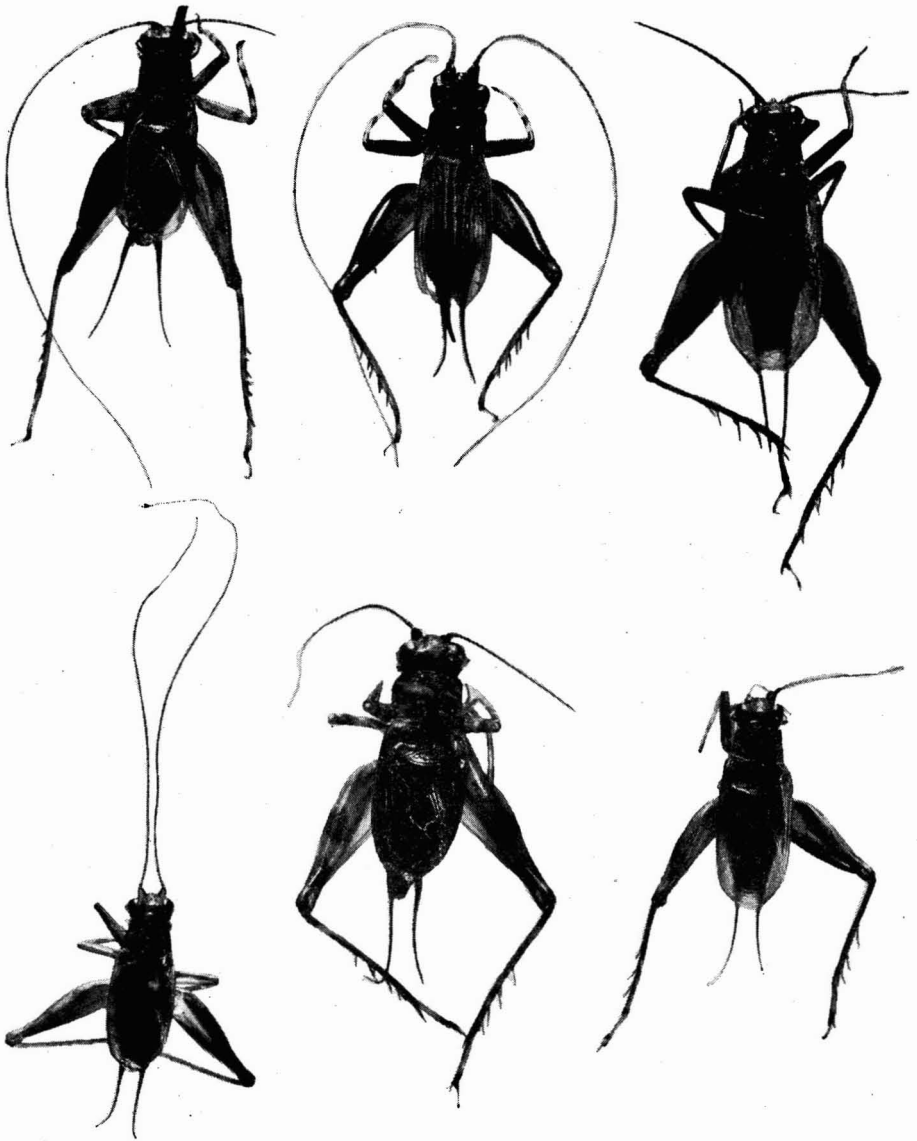


Figure 84—*Paratriginidius* species. Top row, left to right: *P. attenuatum* Perkins; *P. freycinetiae* Perkins (female, all the others are males); *P. grande* Perkins. Bottom row, left to right: *P. molokaiense* Perkins; *P. pacificum* Perkins; *P. subroseum* Perkins. Old specimens such as these make poor subjects for photography.

***Paratriginidius robustum* Perkins.**

*Paratriginidius robustum* Perkins, 1899:20.

Endemic. Kauai (type locality: 4,000 feet, unique male).

Habit: under bark of trees.

I have not seen this species.

**Paratrigonidium roseum** Perkins.

*Paratrigonidium roseum* Perkins, 1899:16, pl. 1, fig. 9. Hebard, 1922:355, fig. 1.

Endemic. Maui (type locality: West Maui, 3,000 feet, unique female).

Hostplant: *Metrosideros*.

**Paratrigonidium saltator** Perkins.

*Paratrigonidium saltator* Perkins, 1899:16. Hebard, 1922:359.

Endemic. Oahu (type locality: above 2,000 feet).

Hostplant: *Freycinetia*.

**Paratrigonidium subroseum** Perkins (fig. 84).

*Paratrigonidium subroseum* Perkins, 1899:17. Hebard, 1922:352.

Endemic. Oahu (type locality: 2,000 feet).

Hostplant: *Metrosideros*.



Figure 85—*Paratrigonidium viridescens* Perkins, male, left; *P. varians* Perkins, male, right.

**Paratrigonidium varians** Perkins (fig. 85).

*Paratrigonidium varians* Perkins, 1899:18. Hebard, 1922:357, pl. 27, figs. 3, 4.

Endemic. Kauai, Oahu, Molokai, Maui, Lanai, Hawaii (type series from Kauai, Oahu, West Maui, and Hawaii).

Habit: arboreal.

**Paratrigonidium viridescens** Perkins (fig. 85).

*Paratrigonidium viridescens* Perkins, 1899:18, pl. 1, fig. 11.

Endemic. Hawaii (type locality: Oloa, 2,000 feet).

Hostplant: "Lives amongst a beautiful creeping fern [*Lindsaya macraeana*? E.C.Z.], which clothes the tree trunks in wet forests" (Perkins, 1899).

**Genus METIOCHE** Stål, 1877

This genus is widespread in the south and western tropical Pacific and Malaya. One species has recently gained entrance to Hawaii.

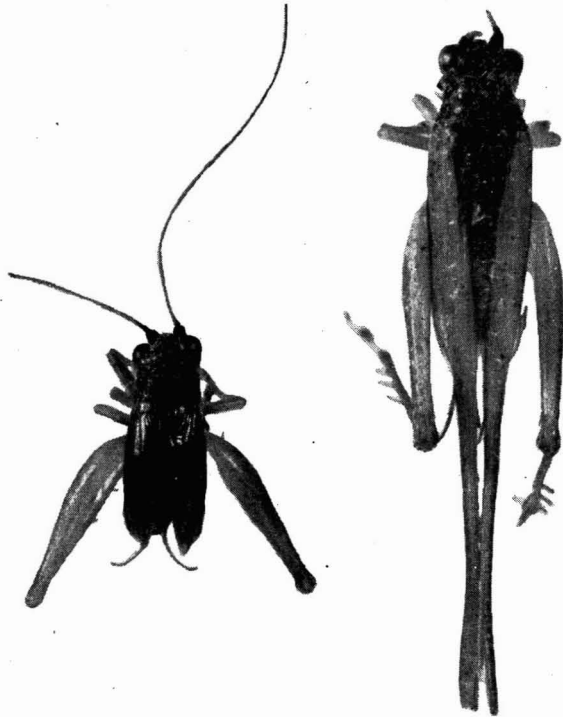


Figure 86—*Metioche vittaticollis* (Stål), brachypterous male, left; long-winged female, right.

**Metioche vittaticollis** (Stål) (fig. 86).

*Trigonidium vittaticollis* Stål, 1860:317.

Kauai, Oahu.

Immigrant. First collected in Hawaii by F. X. Williams late in 1944 among grasses and low herbage in his yard at Makiki, Honolulu. A widespread Pacific species.

Hostplants: feeds on the pollen of various plants such as *Amaranthus*, *Solanum*, *Sonchus* and *Euphorbia*.

This is a pretty, delicate, extremely active little cricket. Its body and wings, in the short-winged forms, are black or nearly so, and the pale greenish-yellow hind legs form a striking contrast in color. The wings of the long-winged forms are brownish. The fully winged individuals are attracted to lights.

The identity of our material needs more detailed checking, I believe.

#### Subfamily ENEOPTERINAE

#### Tribe PROGNATHOGRYLLINI (Perkins) new combination

Group *Prognathogryllides* Perkins, 1899:22.

The Hawaiian assemblage of peculiar and closely allied forms belonging to the Eneopterinae was considered by Perkins to be distinct enough to warrant the erection of a "new group" for them. Whether or not Perkins' "group" is worthy of being called a "tribe," or is enough isolated to be segregated and separately named requires further comparative study by a specialist in Orthoptera. All the genera and species are endemic to the Hawaiian Islands. The entire group evidently had its origin from a *Podoscirtes*-like immigrant allied to certain genera found from Fiji westward. The problem is in much need of review.

These are our most peculiar Orthoptera. All of them are flightless and all have extremely long antennae which are twice as long as the body or longer. The species are nocturnal and can be found hiding in the daytime in hollow stems, limbs, fern fronds and twigs, under dead bark, in clusters of dead leaves in trees, under moss, in dense clusters of ferns, at the bases of *Freycinetia* leaves and *Pritchardia* palm fronds, and in similar places. All the species are arboreal, and they are graceful and beautiful creatures when alive, but dried, shrivelled and misshapen museum specimens leave much to be desired.

Perkins saw drepaniid birds and the "oo," *Acrulocercus braccatus* (Cassin) (Meliphagidae), of Kauai feeding upon these crickets. No records of insect parasites have come to my notice.

## KEY TO THE GENERA OF PROGNATHOGRYLLINI

1. Cerci about as long (male) or longer (female) than hind tarsi  
 ..... **Prognathogryllus** Brunner.  
 Cerci distinctly shorter than hind tarsi..... 2
2. First fore tarsal segment shorter than segments 2 plus 3;  
 second tarsal segments dorso-ventrally depressed.....  
 ..... **Leptogryllus** Perkins.  
 First fore tarsal segment as long as or longer than segments 2  
 plus 3; second tarsal segments laterally compressed.....  
 ..... **Thaumtogryllus** Perkins.

Genus **PROGNATHOGRYLLUS** Brunner, 1895:896

*Aphonogryllus* Perkins, 1899:26.

*Nesogryllus* Perkins, 1899:27.

Synonymy by Perkins, 1910:689.

The males have the tegmina well-developed for stridulation, and they may cover the whole abdomen, but the hind wings are rudimentary.

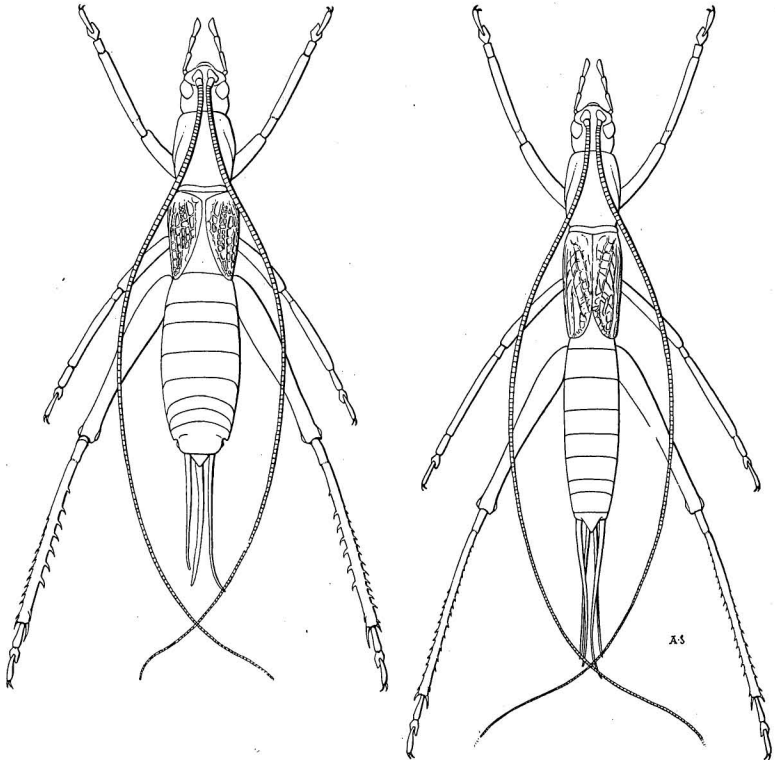


Figure 87—Holotypes of females of *Prognathogryllus alatus* Brunner, left, and *P. elongatus* Perkins, right. (Drawn at the British Museum of Natural History by Smith.)

Swezey found the eggs of a species of this genus inserted in the midribs of the leaves of *Labordia membranacea* on Mount Olympus, Oahu, in 1912. Egg  $6 \times 1$  mm., cylindrical, curved near outer end, inserted at about 10 mm. intervals.

Hebard (1922 and 1926) considered that only *P. robustus*, *P. alatus* and *P. elongatus* were good species, but the types need careful study before any conclusions can be reached. Perkins (in letters) has said that he believes these species to be distinct and does not agree with Hebard.

Without a complete collection at hand, I shall not present a key to the species.

***Prognathogryllus alatus* Brunner (fig. 87).**

*Prognathogryllus alatus* Brunner, 1895:896, fig. 1; genotype, designated by Kirby, 1906:109. Perkins, 1899:24, pl. 2, figs. 8, 8a-b. Hebard, 1922:364, pl. 27, figs. 7, 8, extensive description and discussion.

*Aphonogryllus apteryx* Perkins, 1899:26, pl. 2, figs. 9, 9a-c, described from Oahu.

Endemic. Kauai (type locality: Waimea Mountains, 4,000 feet), Oahu.

Hostplants: *Clermontia*, *Pelea*, *Labordia membranacea* (eggs inserted in midribs of leaves; not the same record as listed above); lobeliads; in hollow fronds of *Cibotium* ferns.

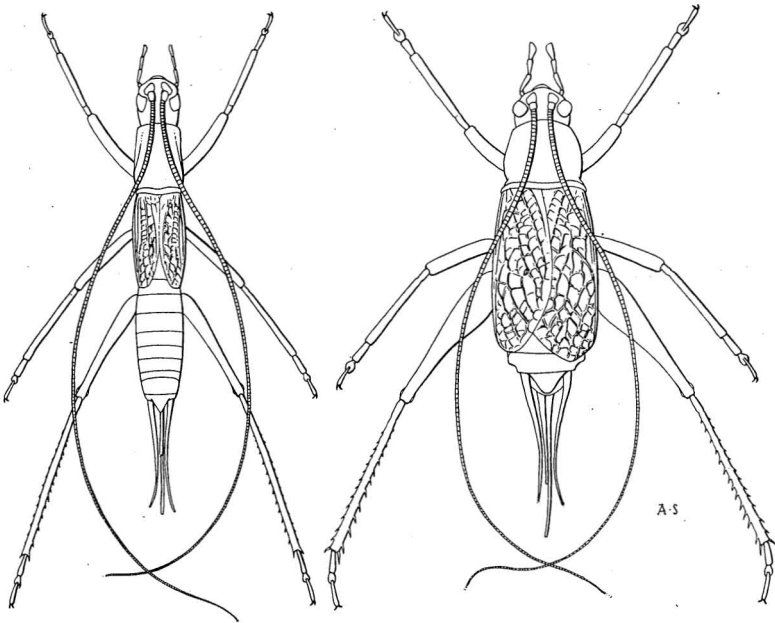


Figure 88—Holotype females of *Prognathogryllus inexpectatus* Perkins, left, and *P. robustus* Perkins, right. (Drawn at the British Museum of Natural History by Smith.)

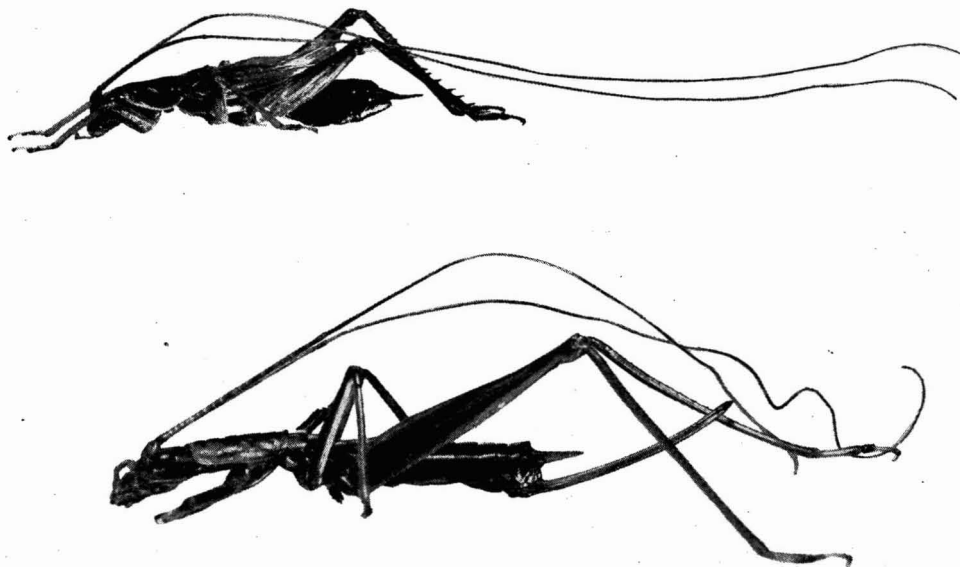


Figure 89—*Prognathogryllus oahuensis* Perkins, male, top (see dorsal view also); *Leptogryllus deceptor* Perkins, female, bottom. (Not to same scale.)

***Prognathogryllus elongatus* Perkins (fig. 87).**

*Prognathogryllus elongatus* Perkins, 1899:25, pl. 1, fig. 15.

Endemic. Kauai (type locality: the high plateau).

***Prognathogryllus inexpectatus* Perkins (fig. 88).**

*Prognathogryllus inexpectatus* Perkins, 1899:25.

Endemic. Kauai (type locality: 4,000 feet).

Found under bark.

***Prognathogryllus oahuensis* Perkins (figs. 89, 90).**

*Prognathogryllus oahuensis* Perkins, 1899:25. Hebard, 1922:368, pl. 27, fig. 9.

*Nesogryllus stridulans* Perkins, 1899:25, pl. 2, figs. 11, 11a; described from a unique male from 3,000 feet on Oahu.

Endemic. Oahu (type locality: Waianae Mountains); also recorded by Hebard (1926:302) from Kauai, Maui and Hawaii, but these records need checking.

Hostplants: *Touchardia* (in dead twigs), *Coprosma*, *Gunnera*, *Labordia*. Also found under bark.

***Prognathogryllus robustus* Perkins (fig. 88).**

*Prognathogryllus robustus* Perkins, 1899:25, pl. 1, fig. 14. Hebard, 1922:364.

Endemic. Kauai (type locality: the high central plateau, unique female).

Found in a cluster of leaves on a dead tree.

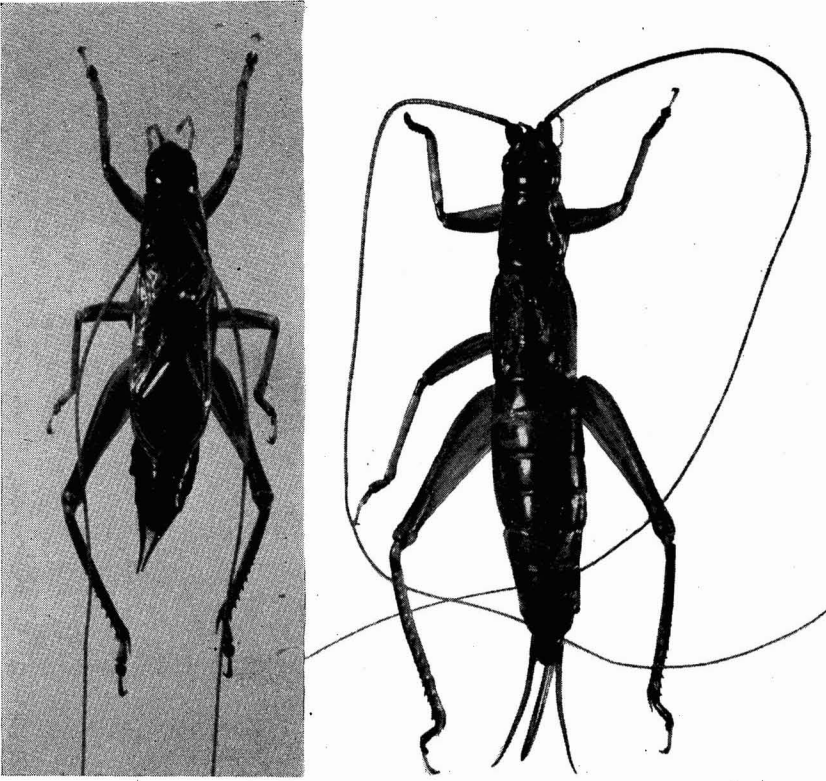


Figure 90—*Prognathogryllus oahuensis* Perkins, male and female (see also lateral view of male in previous figure). (Not to same scale.)

#### Genus **LEPTOGRYLLUS** Perkins, 1899:28

This genus is closely allied to *Prognathogryllus* and *Thaumatogryllus* and has similar habits.

Hebard (1922:370), after studying a series of specimens, but not the types, came to the conclusion that there were only two or three species, instead of the eleven species included by Perkins. He said, "We believe that, of the eleven species described, most are synonyms, based on features which, though often showing marked differences, will be found on more thorough investigation to be valueless from a specific or even from a racial standpoint. In fact it may develop that but a single plastic species exists, breaking into many more or less intergrading phases."

Perkins does not agree with Hebard. I have been able to make a key which outlines some of the differences among the eleven forms named by Perkins, and I am inclined to agree with Perkins rather than with Hebard. Some of Perkins' names perhaps may not be good, but I am led to believe from an examination of some of his type and cotype material that there are a number of good species in this complex. Further critical study in connection with field work may reveal additional species.



As noted below, the types of three of the species are in the Bishop Museum, but the remainder are in the British Museum.

#### KEY TO THE SPECIES OF LEPTOGRYLLUS

1. Hind femora comparatively short, less than 7.5 mm. long.. 2  
Hind femora 8.5 to 12 mm. long..... 4
- 2(1). Hind tibiae with about 10 or fewer spines along inner edge; Maui ..... **simillimus** Perkins.  
Hind tibiae with about 15 or more spines along inner edge;  
Maui and Hawaii ..... 3
- 3(2). Hawaii species ..... **forficularis** (Brunner).  
Maui species ..... **similis** Perkins.  
(Note: these may be the same species, but lack of material makes a decision impossible here.)
- 4(1). Hind tibiae conspicuously black for about the basal three-fourths of their lengths; Maui..... **apicalis** Perkins.  
Hind tibiae not so colored..... 5
- 5(4). Hind tibiae with more than 30 spines in each dorsal row.... 6  
Hind tibiae with less than 25 such spines..... 7
- 6(5). Tegmina extending back nearly to or beyond apex of metanotum and contiguous or nearly so.....  
..... **nigrolineatus** Perkins.  
Tegmina much smaller, extending only slightly behind mesonotum and widely separated, the distance between them greater than breadth of a tegmen.... **deceptor** Perkins.
- 7(5). A slender Kauai species; ovipositor unusually long (about 13 mm.), longer than hind femora; posterior tibiae with about 25 spines in the dorsal rows.... **cyllindricus** Perkins.  
Not such species, ovipositor shorter than a hind femora..... 8
- 8(7). Fore and mid tibiae conspicuously annulate..... 9  
Tibiae not annulate .....10
- 9(8). Kauai species; male tegmina concealing most of metanotum ..... **kauaiensis** Perkins.  
Oahu species; male tegmina reduced to minute flaps easily overlooked beneath hind corners of pronotum.....  
..... **fusconotatus** Perkins.
- 10(8). Kauai species; male tegmina large and covering most of metanotum; female tegmina smaller, but extending about to apex of metanotum..... **nigromaculatus** Perkins.  
Hawaii species; male and female tegmina small and leaving entire metanotum exposed, hardly extending behind mesonotum ..... **elongatus** Perkins.

**Leptogryllus apicalis** Perkins (fig. 91).

*Leptogryllus apicalis* Perkins, 1910:689.

Endemic. Molokai, Maui (type series from both localities).

The male holotype is in the Bishop Museum.

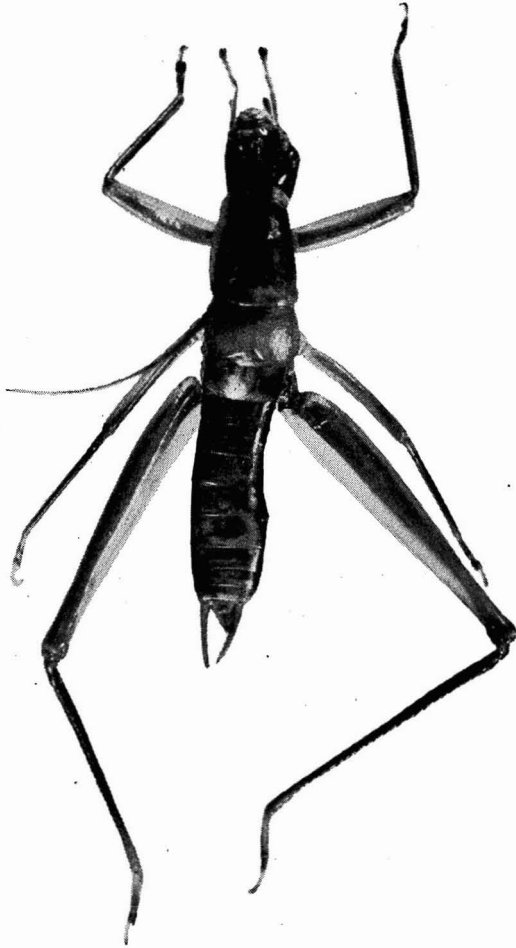


Figure 91—*Leptogryllus apicalis* Perkins, male.

***Leptogryllus cylindricus* Perkins.**

*Leptogryllus cylindricus* Perkins, 1910:688.

Endemic. Kauai (type locality: about 2,500 feet).

The male and female types are in the Bishop Museum.

***Leptogryllus deceptor* Perkins (fig. 89).**

*Leptogryllus deceptor* Perkins, 1910:689.

*Leptogryllus decipiens* Perkins (manuscript name, not published).

Endemic. Oahu (type locality: 1,500–2,000 feet).

The female holotype is in the Bishop Museum.

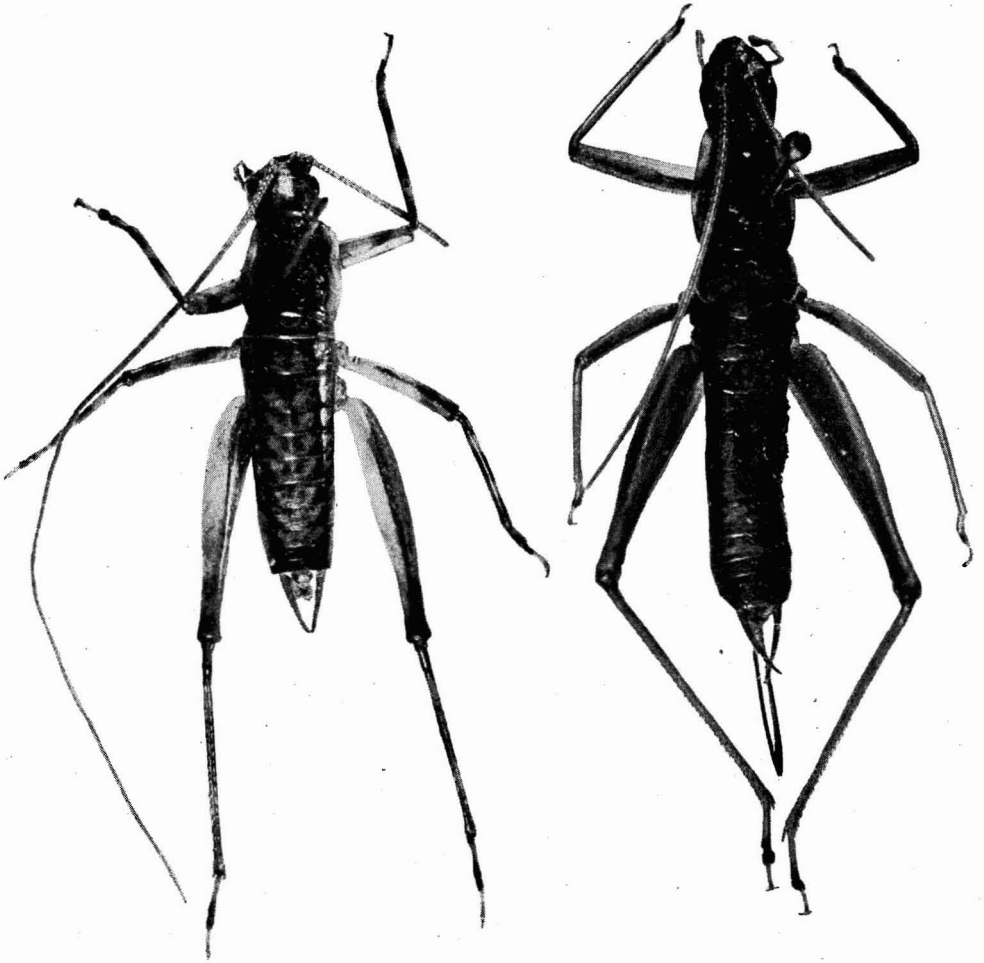


Figure 92—*Leptogryllus fusconotatus* Perkins, male, left; *Leptogryllus nigrolineatus* Perkins, female, right.

***Leptogryllus elongatus* Perkins.**

*Leptogryllus elongatus* Perkins, 1899:29, pl. 1, fig. 18.

Endemic. Hawaii (type series from Hilo, Puna and Kau).

***Leptogryllus forficularis* (Brunner).**

*Prognathogryllus forficularis* Brunner, 1895:897, fig. 2.

*Leptogryllus forficularis* (Brunner) Perkins, 1899:29, pl. 2, figs. 14, 14a-b.

Genotype; designated by Kirby, 1906:110. Hebard, 1922:372, pl. 27, figs. 10, 11.

Endemic. Hawaii (type locality: Kona, 3,000 feet) (Kauai?, Oahu?, Maui?).

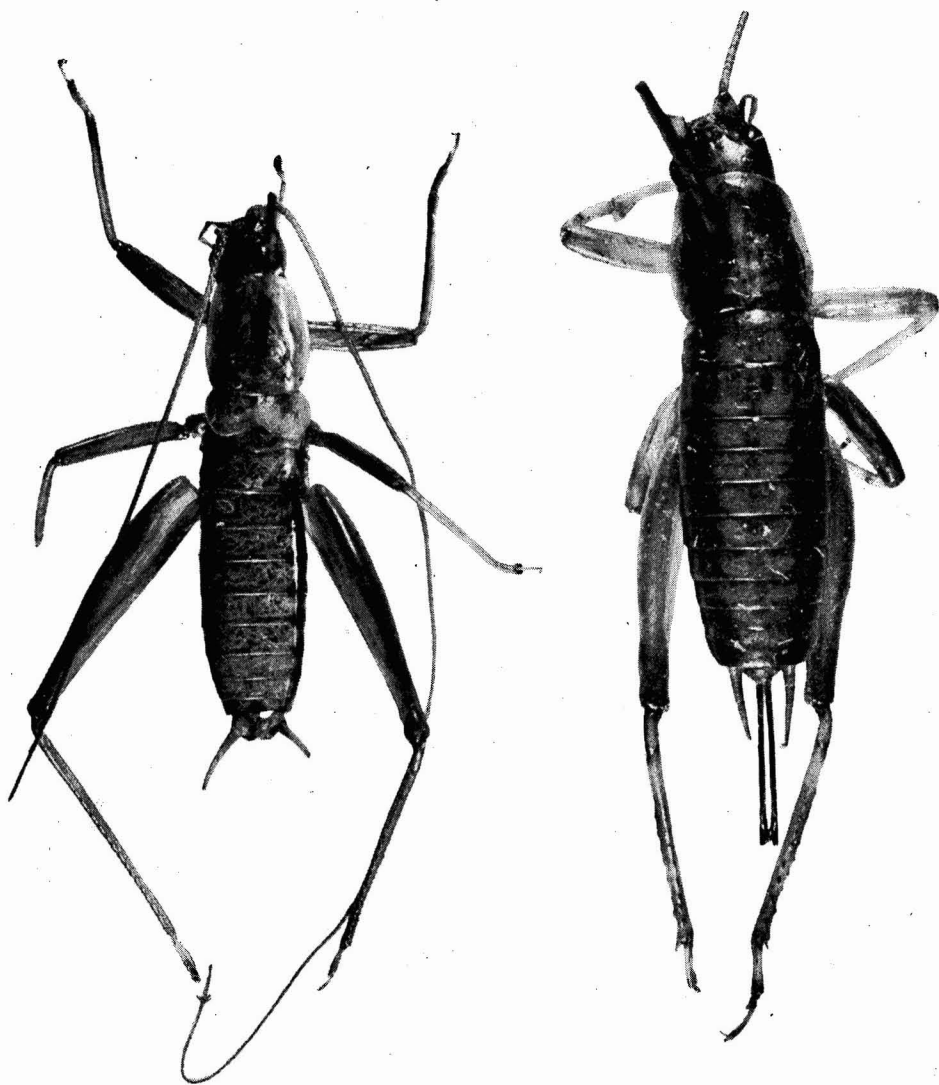


Figure 93—*Leptogryllus nigromaculatus* Perkins, male, left; *Leptogryllus simillimus* Perkins, female, right.

***Leptogryllus fusconotatus* Perkins (fig. 92).**

*Leptogryllus fusconotatus* Perkins, 1899:29.

Endemic. Oahu (type locality: 2,000 feet, unique male).

***Leptogryllus kauaiensis* Perkins.**

*Leptogryllus kauaiensis* Perkins, 1899:29.

Endemic. Kauai (type locality: 2,000–4,000 feet).

**Leptogryllus nigrolineatus** Perkins (fig. 92).

*Leptogryllus nigrolineatus* Perkins, 1899:28.

Endemic. Oahu, Maui, Hawaii (type series from mountains of Oahu and Maui).

Hostplants: at bases of leaves of *Freycinetia*, *Cibotium*.

**Leptogryllus nigromaculatus** Perkins (fig. 93).

*Leptogryllus nigromaculatus* Perkins, 1899:28, pl. 1, fig. 17; pl. 2, figs. 12, 12a.

Endemic. Kauai (type locality: 3,000–4,000 feet).

**Leptogryllus similis** Perkins.

*Leptogryllus similis* Perkins, 1899:28.

Endemic. Hawaii (type locality: above Hilo, 2,000 feet).

**Leptogryllus simillimus** Perkins (fig. 93).

*Leptogryllus simillimus* Perkins, 1899:30, pl. 1, fig. 19; pl. 2, figs. 15, 15a–b.

Endemic. Maui (type locality: 4,000–5,000 feet).

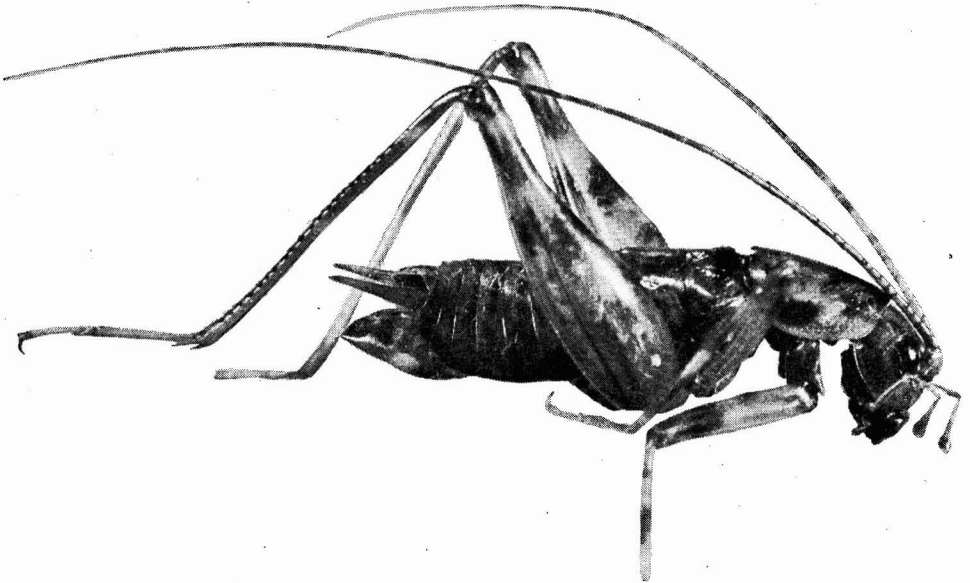


Figure 94—*Thaumatoeryllus variegatus* Perkins, male.

Genus **THAUMATOGRYLLUS** Perkins, 1899:27

The specimens I have examined have the second tarsal segment laterally compressed, a character which, according to current keys to subfamilies, would exclude the genus from the Eneopterinae if used alone. To my knowledge, this character of the Hawaiian species has not been pointed out heretofore. However, this genus is obviously closely allied to *Prognathogryllus* and *Leptogryllus*, and I believe there is no doubt that all three genera have been derived from the same stock.

**Thaumtogryllus variegatus** Perkins (fig. 94).

*Thaumtogryllus variegatus* Perkins, 1899:27, pl. 1, fig. 16; pl. 2, figs. 10, 10a-d.

Genotype. Hebard, 1922:370.

Endemic. Kauai (type locality: 4,000 feet).

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## Order ISOPTERA (Brullé, 1832)

(*isos*, equal; *pteron*, wing)

Termites, White Ants; Hawaiian name: "naonao lele"

Representatives of two of the five living families of termites are found in Hawaii. The primitive family Mastotermitidae and the families Hodotermitidae and Termitidae are not represented. All four of the termites found here are immigrants.

Compound eyes and two ocelli present in the alates, reduced or absent in other castes; antennae moniliform, inserted near the bases of the mandibles, multi-segmented, never much longer than the head; mouth parts generalized (or specialized in soldiers), exposed, masticatory; mandibles strongly developed, extraordinarily so in soldiers of most species, with two articulations with the head; maxillary palpi five-segmented, labial palpi three-segmented; wings (four) present only in reproductive castes, extending far beyond apex of abdomen, folded flat and superimposed over the back when at rest, subequal in size and shape, membranous, without obvious cross-veins in the Hawaiian forms, provided with a subbasal *fracture suture* along which line of weakness the wings may be broken off after the swarming flight (the stump left after the wings are shed is called the *wing scale*); legs similar, ambulatorial; tarsi three- or four-segmented in the Hawaiian forms (the proximal segments small and individually not very distinct in some forms); abdomen ten-segmented, cerci present, small, two-segmented; ninth ventrite with a pair of small cercus-like processes or tubercles in the male (styli); external genitalia not developed in the Hawaiian representatives; eggs deposited in nests, often in extraordinary numbers; nocturnal, xylophagous, soft-bodied, pale-colored (excepting the winged forms), social insects living in wood or soil with highly developed caste systems. Metamorphosis (incomplete) is least in the worker caste and greatest in the reproductives, and the change brought about from nymph to soldier is also striking. There are said to be five to eight molts.

The oldest fossils known are found in Eocene deposits, but these are already advanced, and a long prior evolution is presumed. The primitive Australian *Mastotermes* produces an ootheca and has other characteristics which show relationships to the cockroaches.

Termites are among the most unusual of all the Insecta. Moreover, they are among the most destructive groups of insects, especially in the tropics. About 1,800 species have been described. Although predominantly a tropical group, the distribution throughout the world roughly coincides with the 51° F. mean annual isotherm, which roughly follows the forty-fifth parallel of latitude in both hemispheres. Only a few genera are restricted to temperate regions.

Fortunately for Hawaii, we have only four species, but two of these species are unusually destructive and cause many thousands of dollars damage every year. Although everyone in Hawaii is familiar with the depredations of the group, our species are so insidious and cryptic in habit that little is actually seen or known of the insects themselves—excepting by those who are especially interested in them. We do not have any of the species which build spectacular exposed nests (*termitaria*) such as those found in Australia and elsewhere.

The highly evolved social system of the termites makes the colony an unusually efficient working population. The division of labor, and organization of the population and diverse morphological modifications of the various castes make these astounding animals among the marvels of creation. The social organization of termites might well serve as an ideal model for certain totalitarian human states. Within a colony of *Coptotermes*, for example, labor is carried out by certain individuals only. These individuals have their sexual systems underdeveloped or aborted, and their entire existence is guided by an unfailing instinct for continuous labor. The colony is guarded by highly specialized soldiers, also having aborted sexual organs, whose reason for living is to guard the colony from its foes. Their heads and mandibles are greatly or spectacularly enlarged for defensive action. *Coptotermes* soldiers have an enormous gland which occupies a large part of the body cavity and which produces a copious, sticky, milky fluid which is exuded when the soldier is disturbed. In *Nasutitermes*, which does not occur in Hawaii, the fluid can be squirted at will onto any foe from a gun-like tube opening in the forehead. The sexual forms tend only to migration, colony foundation and reproduction and are the only caste to have wings. In Hawaii the bodies of the reproductive caste only are pigmented and are more heavily sclerotized than those of the soldiers and workers, for members of the reproductive caste are the only ones who venture free into the outer world. Moreover, the eyes of the soldiers and workers are either greatly reduced or are absent, but the reproductives have well-developed compound eyes. Soldiers and workers include both sterile males and females, but whatever their basic sexual anatomy, both males and females act alike as soldiers or workers. The workers are the smallest individuals, the soldiers are somewhat larger, and the reproductives are the largest members of the colony. The duties of the workers are many: they forage for food, feed (by regurgitation) the young nymphs, soldiers and reproductives; they build the *termitaria* and runways and clean and maintain them; they tend the queen and store her eggs in "nurseries." The workers are absent in the primitive termites (*Kalotermitidae*), and their functions are performed by the nymphs of the other castes.

Swarming usually takes place in the spring and early summer. Unlike the swarming of certain Hymenoptera, Diptera and some other insects, the swarming of the termites is not a nuptial flight, for it has been found that mating does not occur until after a new home has been started. After the flight, the male and female join in a pair to found a new colony. Before they bore into wood or enter the soil, they shed their wings. The "fracture suture" at the base of each wing makes it possible for the wings to be discarded easily. The wings serve only to enable the

sexual forms to fly off in search of new colony sites. Once a new burrow is begun, wings are useless and would be a great handicap if retained. The wing-shedding mechanism is thus nicely adjusted to the mode of life of these creatures.

One of the most remarkable of evolutionary associations is the symbiotic relationship between termites (except the Termitidae) and certain kinds of Protozoa. So long has been this association of Protozoa and termites that we now find that allied groups of termites have allied protozoan faunas. Although our termites feed upon wood, they cannot digest sufficient cellulose by themselves. In their hind intestines, however, are seething masses of micro-organisms which include, among many other sorts of organisms, a complement of protozoans. These intestinal Protozoa are capable of breaking down the cellulose taken in by the feeding termite into materials, such as sugars, which the termite can assimilate. The termite thus builds its body tissue from food materials derived as by-products of the Protozoa it harbors in its intestine and from their dead bodies. By artificially removing the vital Protozoa from termites, it has been shown that, although the termites may continue to feed, they will starve in the midst of plenty. The carton material of a *Coptotermes* termitarium is rich in lignin, which is not used by the termites, but the woody material has had its cellulose removed. It is noteworthy that some wood-eating cockroaches also have intestinal Protozoa—some of which are said to belong to the same groups as those found in certain termites.

Dr. Harold Kirby has kindly examined fixed specimens of our termites and is responsible for supplying the names of the protozoans listed below under each of our species.

In most places in the world, remarkably modified insect guests—termitophiles—live in the nests and galleries of various termites. We do not have representatives of these highly specialized insects in Hawaii, however. There are a few apterygotan insects which are occasionally found with termites in Hawaii, but they are not restricted to such habitats.

Termites have many predators. Perhaps the most dangerous enemies to non-swarming termites in Hawaii are ants, several species of which attack termites whenever there is an opportunity. *Pheidole megacephala* is particularly likely to inflict heavy casualties. However, under normal circumstances the termites are well protected from attacks by ants, and it is usually only when some accident befalls a colony that it is exposed to attack by ants in Hawaii. At the time of swarming, the reproductives are most vulnerable to attack. If swarming takes place in daylight (as it does occasionally, although it normally takes place at night), dragonflies, skinks, mynah birds and sparrows gorge themselves on the flying termites. At night geckoes and *Bufo* toads take over the slaughter. Geckoes are particularly helpful in reducing the numbers which might enter houses by taking up their hunting stations on windows, screens and ceilings and capturing with insatiable appetites the swarming termites which are attracted to lights. The introduction of bats to Hawaii probably would aid greatly in the reduction of the numbers of swarming termites. The single native Hawaiian bat is rare and local in habit and

is not regularly attracted to the lowlands where termites are abundant. Pemberton (1928:147) found a lepismatid living in the nests and galleries of certain termites in Borneo and feeding upon the termite eggs and nymphs. A single attempt to introduce the species into Hawaii did not succeed because of the death of the small colony before the specimens could be released. No really useful methods of biological control of termites have yet been found. Artificial control is discussed under *Cryptotermes* and *Coptotermes*.

The reader is referred to the several general textbooks for a detailed account of the order.

TABULAR ANALYSIS OF THE HAWAIIAN ISOPTERA

FAMILY	GENERA	ENDEMIC GENERA	NON- ENDEMIC GENERA	SPECIES	ENDEMIC SPECIES	ADVENTIVE SPECIES
Kalotermitidae	3	0	3	3	0	3
Rhinotermitidae	1	0	1	1	0	1
Totals	4	0	4	4	0	4

Fauna 100 percent adventive.

Average number of species per genus: 1.

KEY TO THE FAMILIES OF ISOPTERA FOUND IN HAWAII

1. Alates ..... 2  
Soldiers ..... 3
- 2(1). Wings not hairy, radial sector with several distinct, anteriorly inclined branches, especially distinct toward apex; anterior wing scales very large and broadly overlapping hind wing scales ..... **Kalotermitidae.**  
Wings densely clothed with fine hairs, radial sector without branches; fore wing scales at most narrowly overlapping hind wing scales ..... **Rhinotermitidae.**
- 3(1). Mandibles strongly toothed; frontal pore absent.....  
..... **Kalotermitidae.**  
Mandibles not toothed; frontal pore conspicuous and from which is exuded a sticky, milky fluid..... **Rhinotermitidae.**

A field character useful for distinguishing the two families in Hawaii is that the members of the Kalotermitidae produce characteristic sand-like fecal pellets (frass or "termite dust" or "termite sand" or "termite sawdust") which are to be found in quantities in their burrows and which are periodically cast out of the burrows (except in the mountain-dwelling *Neotermes*, in which species the pellets are not loose but are massed together). On the other hand, the excrement of the Rhinotermitidae is not produced in pellet form, but goes directly into the construction of nests and galleries. Thus, wood damaged by Kalotermitidae or dry-

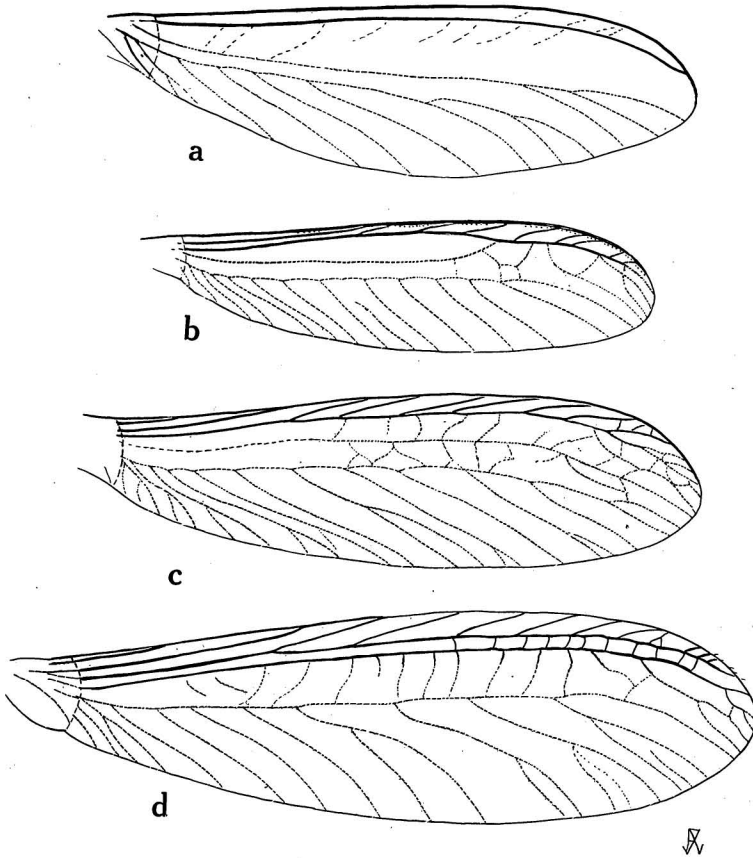


Figure 95—Sketches of fore wings of termites: **a**, *Coptotermes formosanus* Shiraki; **b**, *Cryptotermes brevis* (Walker); **c**, *Kalotermes immigrans* Snyder; **d**, *Neotermes connexus* Snyder. Note the subbasal fracture sutures. (From the original drawings by Williams, 1931.)

wood termites will be found to contain pellets, whereas wood tunneled by Rhinotermitidae will contain no pellets. Also, the Rhinotermitidae build carton nests and covered runways, neither of which structures is built by the Kalotermitidae. The workers of all forms having workers are closely similar (no true worker caste is found in the Kalotermitidae).

#### Family KALOTERMITIDAE (Enderlein) Banks, 1920

*Calotermitidae* Enderlein, 1909.

There are three species of this family found in Hawaii. One is a serious pest, but the other two are insects of field and forest. All three species are "dry-wood" termites. They can establish themselves in dry wood by boring directly through the surface and setting up a colony without access to soil moisture. Unlike *Copto-*



*termes*, the species of this family do not have a true worker caste, and the work is largely carried on by nymphs of the sexual forms. Unlike *Coptotermes*, the colonies of our species of Kalotermitidae are small—frequently not more than 100 individuals. On the other hand, the colonies may be numerous and the excavations of several colonies in the same piece of wood may overlap.

There has been confusion in the use of *Kalotermes* or *Calotermes*, and hence the varied spelling of the family name. The original spelling was with a "K," and because Opinion 34 of the International Rules of Zoological Nomenclature states that "Since evidence of the derivation of the word is not contained in the original publication, the original spelling . . . should be preserved" appears to apply in this case, the spelling should be *Kalotermes*.

#### KEY TO THE GENERA AND SPECIES OF KALOTERMITIDAE FOUND IN HAWAII

1. Alates ..... 2  
Soldiers ..... 4
- 2(1). Fore wings with median vein heavily sclerotized (similar to radius), closely paralleling radial sector and with obvious branches to it; the largest Hawaiian species with breadth of head across eyes exceeding 1.5 mm. .... **Neotermes connexus** Snyder.  
Fore wings with median vein very faint, not sclerotized as is radial sector; head less than 1.5 mm. wide. .... 3
- 3(2). Median vein of fore wings lying about midway between radial sector and cubitus and not curving up to join radial sector; head closer to 1.5 mm. broad than to 1.0 mm. .... **Kalotermes immigrans** Snyder.  
Median vein of fore wings curving up to join radial sector near middle; head closer to 1.0 mm. broad than to 1.5 mm. .... **Cryptotermes brevis** (Walker).
- 4(1). Head short and squarish, its front conspicuously truncated, nearly vertical in front of antennae, the truncated vertical area concave and coarsely wrinkled as is dorsal area in back of declivitous region. .... **Cryptotermes brevis** (Walker).  
Head not so formed, elongate, front gently sloping. .... 5
- 5(4). Third antennal segment longer than following two combined; pronotum about three-fourths as broad as long, its anterior margin broadly, deeply and conspicuously emarginate. .... **Kalotermes immigrans** Snyder.  
Third antennal segment only about one-fourth longer than fourth; pronotum less than one-half as broad as long, its anterior margin shallowly concave. .... **Neotermes connexus** Snyder.

#### Genus **CRYPTOTERMES** Banks, 1906

This genus is found in both the Old and New Worlds and is known from Pleistocene fossils.

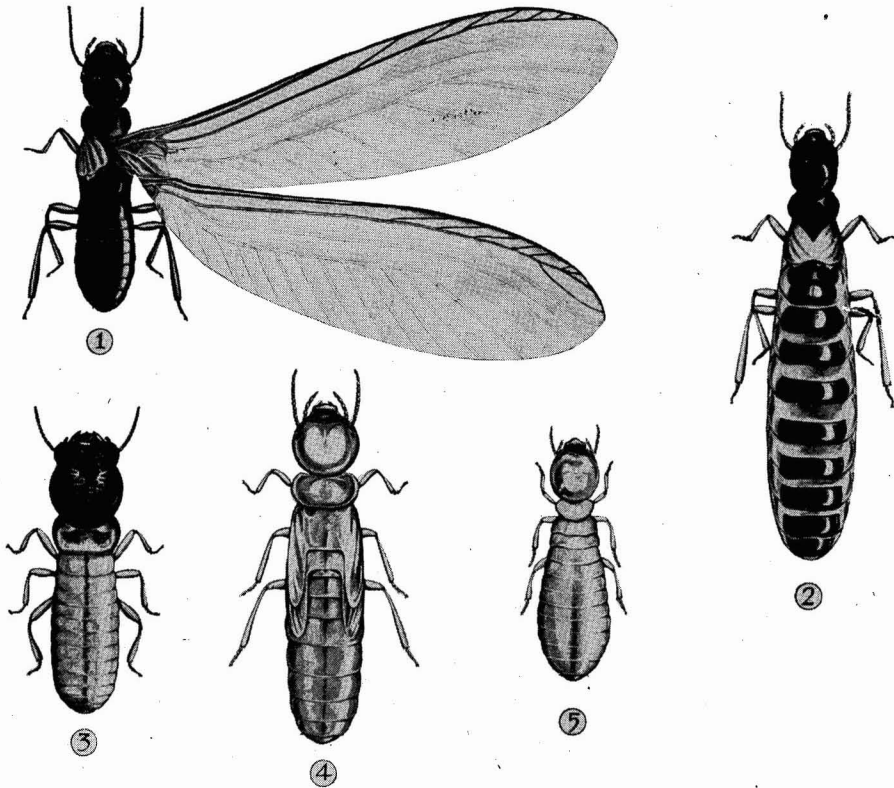


Figure 96—*Cryptotermes brevis* (Walker), the dry-wood termite. 1, winged adult; 2, dealated gravid queen; 3, soldier; 4, full-grown nymph; 5, young nymph. (From a painting in the Board of Agriculture and Forestry, Honolulu. Courtesy of D. T. Fullaway.)

***Cryptotermes brevis* (Walker) (figs. 95b, 96, 97, 98).**

*Termes brevis* Walker, 1853:524.

*Cryptotermes piceatus* Snyder, 1922:14, pl. 5, figs. 18, 19.

The dry-wood termite; powder-post termite.

Kauai, Oahu, Molokai, Lanai, Maui, Hawaii, Lisianski.

Immigrant. Tropical America, Florida, South Africa, China, Marquesas Islands. Evidently in Hawaii before 1869. A species widespread by commerce. Some of the early Hawaiian records of damage by *Kalotermes immigrans* really apply to this species.

Hostplants: probably most kinds of dry wood in houses and buildings. No detailed list of the kinds of wood attacked is available, but in addition to many kinds of wood commonly used in buildings and furniture, the termite has been found attacking *Grevillea robusta*, *Acacia koa*, *Eucalyptus*, *Nothopanax*, *Metrosideros* ("ohia lehua") and old redwood. It will bore through books, tar-paper and other materials.

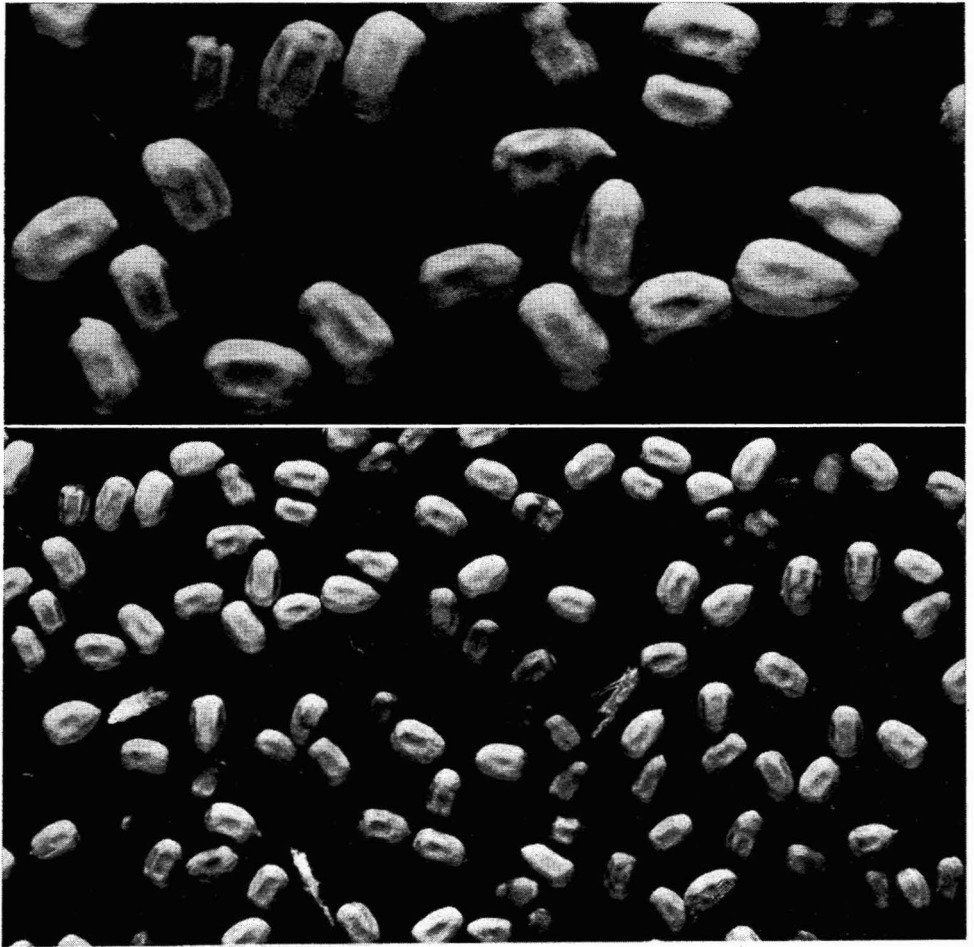


Figure 97—Greatly enlarged photographs of the fecal pellets of *Cryptotermes brevis* (Walker), the dry-wood termite.

Symbiotic flagellate protozoans: *Foaina humilis* Kirby (1942), *Devescovina striata* Foà (1905), *Tricercomitus divergens* Kirby (1930), *Hexamastix conclaviger* Kirby (1930), *Calonympha* sp. (probably *C. grassi* Foà, 1905).

This is a pest of the first order in Hawaii. It is the termite which so commonly damages wooden furniture of all kinds and may be found in almost anything made of wood. The annual damage done here amounts to hundreds of thousands of dollars. In founding a colony, the reproductives take advantage of any small crack, joint or hole (such as a nail hole) which they can find and commonly begin their tunneling from such a vantage point. After penetration is accomplished, the male and female tunnel along the grain of the wood, establish a nest and the female lays a few eggs. When the tunnels become crowded, an exit hole is bored to the exterior and quantities of the fecal pellets are pushed out. Such exit holes are closed with a brown parchment-like material. This habit makes the presence of the

termites known and is usually the first indication that an infestation exists in any article or situation. A focus of infestation is usually easy to locate directly above any pile of pellets. In houses and other buildings, infestations frequently begin in attics, and from there spread to all parts of the structures. Proper screening of all openings to attics will aid greatly in reducing infestations. Ehrhorn's (1934:302) recommendations for the control of this species are as follows:

Badly infested timbers or woodwork should be removed wherever possible, and the new timber or woodwork should be thoroughly treated with creosote or other substance before replacement. Slightly infested timbers or woodwork can be treated as follows with some success: Foundation timbers and timbers in unfinished attics, with creosote either with brush or spray gun; interior finish, such as door frames, window frames, floors, etc., with Paris green, powdered arsenic or sodium fluosilicate. In Hawaii we have had very good results with both methods. In treating an attic, we first use a vacuum cleaner, which removes all the pellets, dust, and other matter from the floor and other places. We then treat all visible infestations, either by the wet or dry method. After a week or two a reinspection is made, and wherever new droppings of pellets are found a close examination will reveal an over-looked infestation, which is then treated. Under such a system a thorough killing or extermination can be accomplished. The dry treatment, using Paris green or other poisonous material for interior finish, has given splendid results. In attics where the ventilators have been covered with fine mesh monel wire we find conditions better, with very few infestations, but where the ventilators are not covered the infestations are usually extensive.

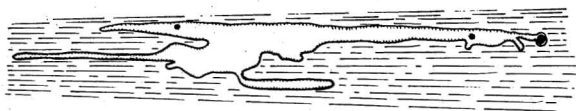


Figure 98—A sketch of a burrow of *Cryptotermes brevis* (Walker) in a pine board. The point of entry of founders of the colony is the nail hole at the right.

When infestation occurs in furniture, the best possible method of control is to have the entire piece placed in a fumigating vault and thoroughly treated with cyanide, methyl bromide or similar fumigant. This method is, however, not always convenient or practicable to the individual homeowner, but larger institutions will save material and money by having a simple fumigating vault available. Entire rooms or whole buildings can be fumigated by experienced workers. With proper fumigation, the whole infestation in any given article can be destroyed in a single treatment. However, fumigation must be done carefully, and it takes long and thorough penetration to kill the termites deep inside the wood. Unbroken paint and varnish surfaces may be almost gas proof. Rapid, superficial fumigation will not give satisfactory control. In articles which cannot be fumigated without excessive effort or expense, the following method will give excellent results if applied properly. Ascertain the source of the termite pellets (an ice pick makes a good probe), and when the burrows are encountered, carefully make a small opening through the surface, then with a "puffer" or dust gun, blow in a charge of Paris green, sodium arsenite, sodium fluosilicate powder or other recommended poison dust. After treatment, the openings should be carefully plugged. If a colony has just begun, a single treatment may kill out the infestation. An entire colony may on occasion be exterminated by dusting only a single individual with poison. With

a good dust gun producing ample pressure, the dust can often be forced to almost all parts of a burrow system. Orthodichlorobenzene injected into the burrows with a hypodermic type of applicator is another recommended method of control. (Extreme care should be exercised with all such poisonous substances!) Wolcott (1945:444) found copper pentachlorophenate to be an effective "repellent" for use in protecting woods from attack by this species in Puerto Rico, and local workers who tried the material report good results. DDT has come into general use since this text was written, and it will undoubtedly be used extensively in control work.

This species has seriously damaged wooden frames and wooden parts of the tops of the older model automobiles in Hawaii. Damage was so severe to passenger and freight cars that the Oahu Railway and Land Company built a dry-heat chamber 75 feet long to use in controlling this termite. The temperature in the vault was raised to 150° F. by passing steam under 90 pounds pressure from a locomotive through radiator pipes lining the walls of the vault. Success was obtained with 1.5 hours exposure.

This species swarms usually in the spring, beginning on warm evenings and nights in May, particularly after rains. As a result of swarming, the number of colonies may be greatly increased in a building. Some property owners keep a low wattage electric bulb burning over a large pan of oiled water in their attics during the warmer months of the year. When the swarms emerge, the termites are attracted to the light, fall into the water and are drowned. This method will undoubtedly reduce the number of new foci of infestation. An effort should be made to keep termites from gaining entrance to buildings when swarming occurs. Open doors and unscreened or poorly screened windows and other openings through which the termites can fly when attracted to lights are commonly the sources of infestation.

Wood is not infrequently infested before it is used in construction, and care should be taken not to use old or second-hand lumber when there is a possibility that it contains colonies of *Cryptotermes*. Newly imported, freshly sawed lumber may easily become infested after delivery to the site of a new building, or it may become infested during fabrication. Moldings, window frames and cases, battens, stairways, floors, doors, ceilings, walls, underpinning, joists and other essential parts of houses are subject to attack and should be checked periodically.

This termite works in much smaller colonies and much slower than does *Coptotermes* and does not cause great damage in short periods of time. Its action is gradual and cumulative, and its attacks can be reduced to a minimum by vigilant care of property. Good paint and varnish finishes are deterrents to colony establishment.

The habits of this species make it easy to disperse, for it commonly infests packing cases, crating lumber, picture frames, boxes, barrels and wooden articles which are sent far and wide. The world will hear much more of this termite in the future than it has in the past, for it is sure to become widespread.

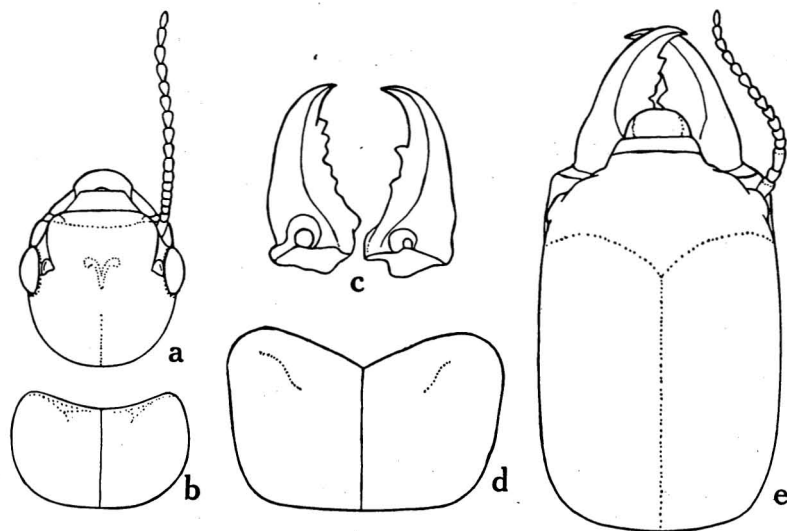


Figure 99—*Kaloterмес immigrans* Snyder. a, b, head and pronotum of alate; c, d, e, mandibles, pronotum and head of soldier. All drawings to same scale. (Redrawn from Light, 1932:75.)

### Genus **KALOTERMES** Hagen, 1853

Species of *Kaloterмес* have been described from Oligocene, Miocene and Pleistocene fossils, and today the genus is widespread about the world.

***Kaloterмес immigrans*** Snyder (figs. 95, c; 99, a-e; 100).

*Kaloterмес immigrans* Snyder, 1922:2, pl. 4, fig. 15.

*Kaloterмес marjoriae* Snyder, 1924:3, pl. 1, fig. 6 (type locality: Hilo, Hawaii).

The lowland tree termite.

Kauai, Oahu (type locality: Honolulu), Maui, Hawaii.

Immigrant. Ecuador, and the Line, Marquesas and Galapagos Islands. First recorded from the Hawaiian Islands by McLachlan in 1883 (under the incorrect name *Caloterмес marginipennis* Latreille).

Hostplants: common in many dead trees in the lowlands including *Acacia farnesiana*, algaroba (abundant, especially in the drier regions), *Eucalyptus*, *Gossypium tomentosum*, guava, *Hibiscus*, *Kadua*, *Lantana*, *Myoporum sandwicense*, *Nothopanax*, oleander; occasionally in fence and other posts, telephone poles and boards, but only under rare circumstances has it been found in buildings.

Symbiotic flagellate protozoans: *Tricercomitus divergens* Kirby (1930), *Coronympha clevelandi* Kirby (1929), *Trichonympha subquasilla* Kirby (1932), *Oxymonas* sp.

This is our second largest termite. It is especially abundant in algaroba groves, and it does not extend its range far into the mountains. The excrement is produced in characteristic loose pellet form.

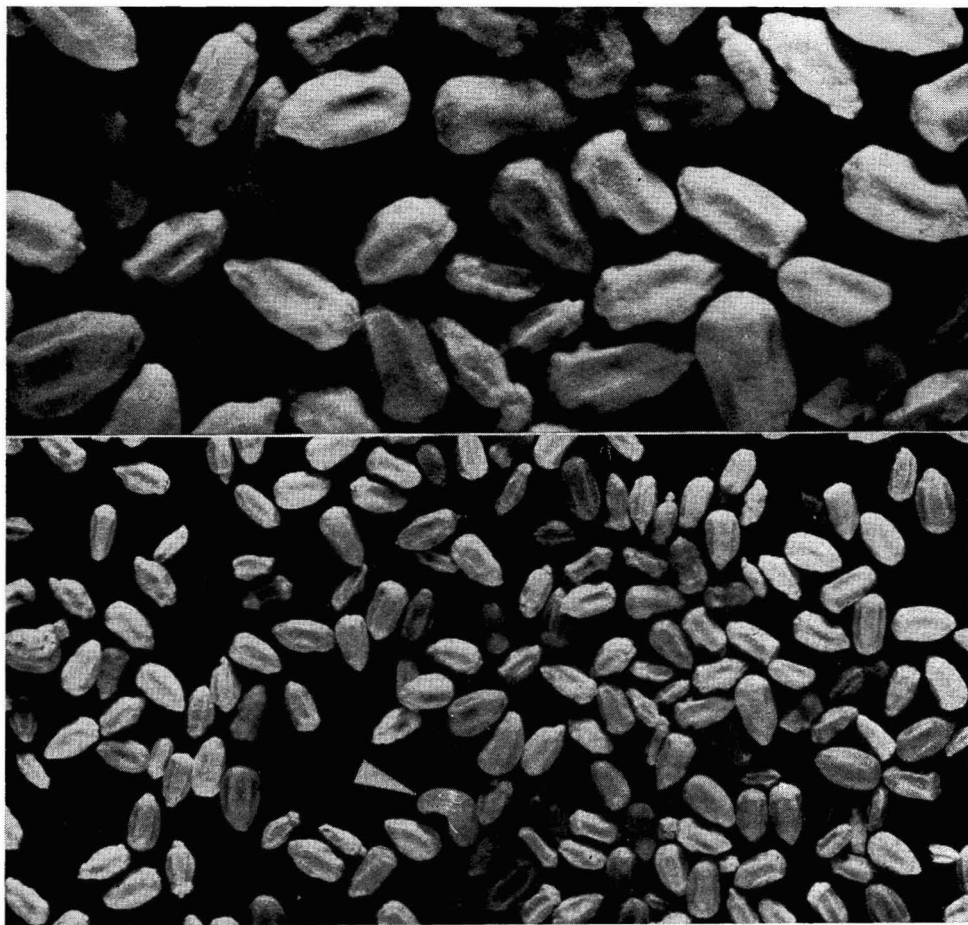


Figure 100—Greatly enlarged figures of the fecal pellets of *Kalotermes immigrans* Snyder, the lowland tree termite. Note the collapsed egg marked by the arrow in the lower figure.

### Genus **NEOTERMES** Holmgren, 1911

Fossil *Neotermes* are known from Pleistocene deposits. The genus has a wide spread contemporary distribution.

**Neotermes connexus** Snyder (figs. 95, d; 101, a-e).

*Neotermes connexus* Snyder, 1922:9, figs. 3, 4; pl. 4, fig. 16.

*Neotermes connexus* variety *major* Snyder, 1922:11 (type from Kaiwiki, Hawaii); 1924:383, description of soldier.

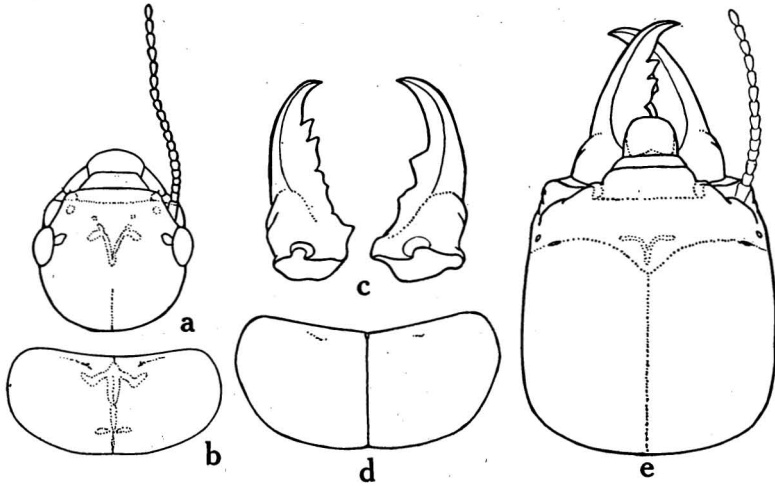


Figure 101—*Neotermes connexus* Snyder. a, b, head and pronotum of alate; c, d, e, mandibles, pronotum and head of soldier. All drawings to same scale. (Redrawn from Light, 1932.)

#### The forest-tree termite.

Kauai (type locality), Oahu, Molokai, Lanai, Maui, Hawaii.

Immigrant. Evidently widespread in the Pacific: Marquesas, Society, Samoa (?), Ellice (?), and Guam islands. First recorded from Hawaii by McLachlan in 1883 (under the erroneous name *Calotermes castaneus* Burmeister).

Hostplants: *Acacia koa*, *Broussaisia*, *Byronia*, *Callophyllum*, candle nut, *Clermontia*, *Coprosma*, *Freycinetia*, *Gouldia*, guava, *Hibiscus tiliaceus*, *Lantana*, *Metrosideros*, *Pandanus*, *Perottetia*, *Pipturus*, *Straussia*, *Suttonia*, *Tetraplasandra*.

Symbiotic flagellate protozoa: *Foaina solita* Kirby, *Foaina gracilis* Janicki, *Foaina nana* (Kirby), *Devescovina hawaiiensis* Janicki, *Devescovina exilis* Kirby, *Parajoenia grassii* Janicki, *Tricercomitus divergens* Kirby, *Oxymonas granulosa* Janicki, *Stephanonympha silvestrii* Janicki.

This is the largest termite in Hawaii; the length of the alates may reach nearly 20 mm. It is typically a forest insect which may range from 500 feet up to about the 5,000-foot level. It requires a higher moisture content in the wood in which it lives than does either *Cryptotermes* or *Kalotermes*. It is common in dead stumps, logs, limbs and dead parts of living trees. Giffard recorded it feeding upon living wood of forest trees, but this and other such records are misleading, because the termites probably originally had attacked dead or decaying parts of the trees. The excrement of this species is not produced in loose pellet form; the pellets are massed in the excavations.

Pemberton (1928:149) recorded a parasitic nematode from the heads of specimens of this termite.



## Family RHINOTERMITIDAE

Fortunately, only one species of this group of wood destroyers has gained entrance to Hawaii. However, the one species present does an enormous amount of damage every year.

Unlike the other termites found in Hawaii, the reproductive forms of *Coptotermes* cannot successfully establish themselves in perfectly dry wood. They must have plenty of moisture to carry on their vital processes. Also, unlike the Kalotermitidae, *Coptotermes* has a worker caste which is distinct from the working nymphs of the Kalotermitidae. The soldiers have a large and conspicuous frontal pore through which can be exuded at will a sticky, milk-colored fluid derived from an enormous gland which occupies much of the cephalic, thoracic and abdominal cavities. This fluid is used for defensive purposes—especially against ants.

These termites construct covered runways whenever they leave the ground or wood in which they are feeding in search of other food supplies. The covered runways not only serve to protect the termites from their enemies, but, most important of all, they enable the colonies to maintain the all-important high humidity essential for their well-being. Dr. Alfred Emerson, University of Chicago, informs me that they are "neutral" to light, and that they are not strongly negatively phototropic as is commonly believed.

Genus **COPTOTERMES** Wasmann, 1896

This genus has not been found in the fossil state, but species are now found in both Eastern and Western Hemispheres and are largely, but not entirely, confined to the tropics.

**Coptotermes formosanus** Shiraki (figs. 95, a; 102–109).

*Coptotermes formosanus* Shiraki, Trans. Ent. Soc. Japan 2:239, 1909. (I have not seen this reference.)

*Coptotermes intrudens* Oshima, 1920:262, pl. 7, figs. a–i (type locality: Honolulu).

The subterranean termite.

Kauai, Oahu, Lanai, Hawaii.

Immigrant. China, Formosa, Japan. First recorded from Hawaii by Swezey in 1913 when it was found in the chapel of Kamehameha School near Bernice P. Bishop Museum. However, Perkins had first discovered it in "1907 or earlier" in Honolulu.

Symbiotic flagellate protozoans: *Pseudotrichonympha grassii* Koidzumi, *Holomastigotoides hartmanni* Koidzumi, *Sperotrichonympha leidyi* Koidzumi.

The habits of *Coptotermes* make its distribution to widely separated localities less likely than that of *Cryptotermes*, which can be carried in almost any piece of dry wood. Therefore, *Coptotermes* has not become established on all of the main Hawaiian islands as has *Cryptotermes*. Some years ago some sprouted coconuts

from Oahu were transplanted on Maui. The damp husks of some of the coconuts were infested with incipient colonies, and the species became temporarily established on Maui. However, prompt attention resulted in the extermination of the localized Maui infestation. Small colonies of the species have been intercepted by plant quarantine inspectors at Honolulu in banana stumps from Manila and yams from Hongkong. The importation of potted plants from regions occupied by the termite is a great potential source of infestation, because small colonies may be established in the soil of the pots. The first record of the termite from Kauai was in 1928. On Lanai, careful attention has been given to the control and attempted eradication of the pest, and its distribution on that island is restricted.

The subterranean termite evidently first became established along the waterfront in Honolulu, and from there it has radiated outward. It has followed especially

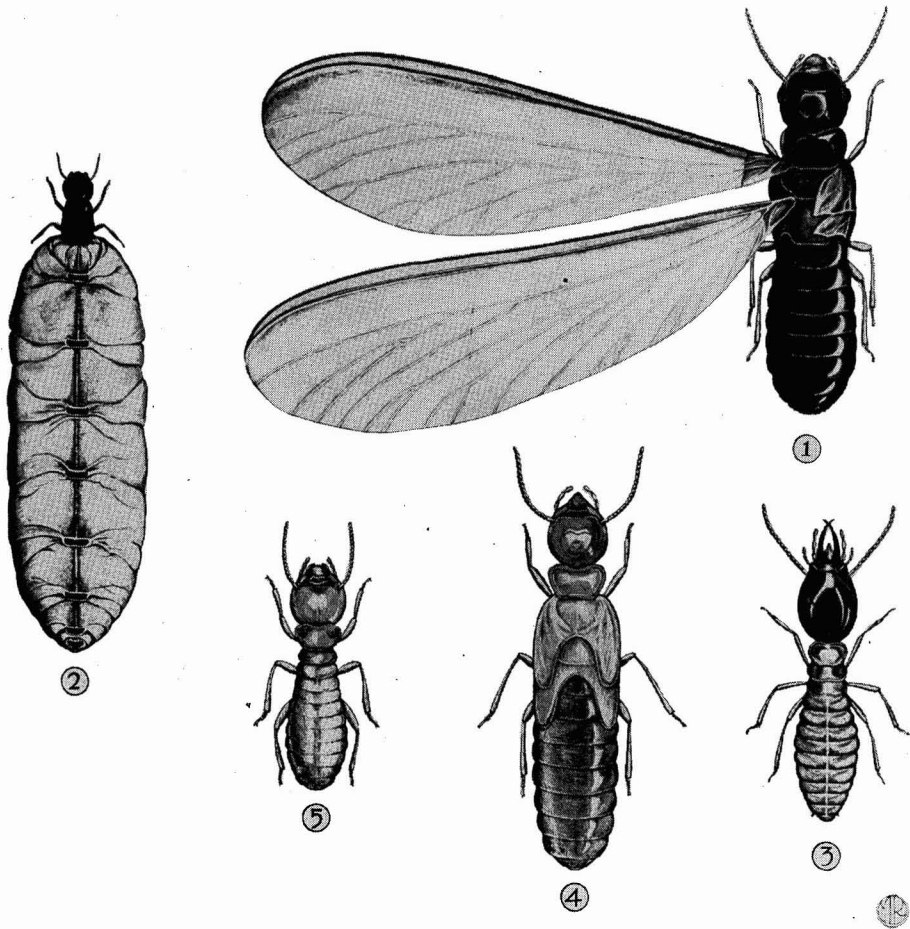


Figure 102—*Coptotermes formosanus* Shiraki, the subterranean termite. 1, winged adult; 2, gravid queen with body distended with ovaries and eggs; 3, soldier; 4, nymph of sexual or winged form showing developing wings; 5, worker. (From a painting in the Board of Agriculture and Forestry, Honolulu. Courtesy of D. T. Fullaway.)

utility pole lines and streetcar routes. Some observers believe that swarming individuals after being attracted to the lights of streetcars have been dispersed along the route by the moving cars. The infestations become noticeably fewer and fewer as one proceeds away from the center of Honolulu toward the mountains, but more and more reports are coming in from areas heretofore unoccupied by the termite, and it is obvious that it is still spreading.

No other insect in Hawaii causes as much damage to wooden structures as does this species. No estimates of the annual monetary losses are available, but they are great. Almost no kind of untreated wood or cellulose product is exempt from its ravages. When ample moisture is unavailable, the termites even turn to growing plants and are known to have damaged or killed many kinds of trees and sugarcane, corn, geraniums, *Coleus*, *Nothopanax*, *Bixa orellana* and other plants.

No detailed study has yet been published of the variety of materials eaten by this termite in Hawaii, but it is unusually wide. Oshima (1919) reported that teak (*Tectona grandis*) and Australian cypress pine (*Callitris robusta*) were immune to attack by this species. Camphor wood (*Cinnamomum camphora*), molave (*Vitex parviflora*) and ipil (*Intsia bijuga*) are comparatively resistant woods. In Honolulu old redwood in the ground (normally a fairly resistant wood), *Metrosideros* ("ohia lehua"), "Celotex," "Canec," "Masonite," coconut and a number of other woods and wood products have been reported attacked. Clothing and bolts of cloth, cotton, books, all kinds of paper, even heavily tarred paper, and such materials are damaged severely when accessible.

Optimum moisture is an absolute essential to this species, and when an adequate quantity is unavailable, the colony dies out. The species normally has a subterranean nest, but if a constant supply of moisture is available in buildings, even several stories above the ground, no contact with the soil is needed for a nest to be constructed. Nests are not infrequently found on the roofs of concrete buildings. These termites carry damp soil into their extended runways in order to maintain proper humidity. This habit often causes heavy growths of molds to grow in closed cabinets or closets which become infested, and the heavily infested parts of buildings may become musty-smelling.

Incipient colonies normally gain their start in or near the soil where adequate moisture and damp wood are available. The nests are normally built in the soil—usually at or near the bases of utility poles, tree stumps or near some other underground food source—but under favorable circumstances the nests may be found almost anywhere. Thus strong colonies may be established in boats, ships, barges, dredges, water tanks, piers or any similar place where moisture and cellulose are available. The structure of the nest is characteristic (see figures 105, 106) and is made of "carton." "Carton" is a term which has been applied to the friable substance constructed of soil and masticated woody substances cemented together by saliva and excrement of the termites. The runways are similarly constructed. The nests may be several cubic feet in size, and a single colony may contain several

hundred thousand individuals. The colony grows slowly at first, but momentum later is gained, and rapid increase sets in when the queen starts to lay as many as a thousand eggs a day. For a few to several days after pairing, no eggs are laid, then about two dozen eggs are deposited at the rate of one to four a day. The young queen then stops laying until her brood hatches (see Oshima, 1919). A mature queen is little more than an enormously expanded, fat, potato-like, egg-laying machine. She is locked in a "royal chamber" where she is at all times cared for by numerous "nurse" termites. If the queen dies, supplementary queens may develop within the colony under favorable conditions.

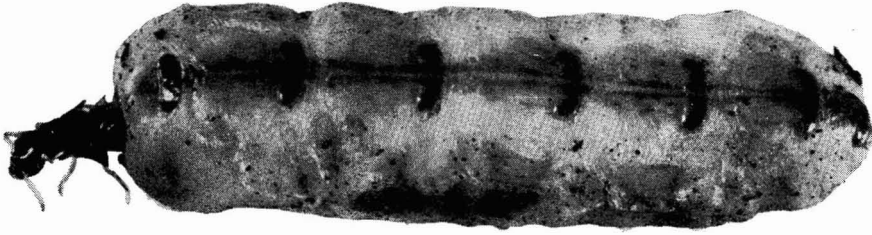


Figure 103—*Coptotermes formosanus* Shiraki. A gravid queen, 26 mm. long. The dark "islands" on the dorsum of the abdomen are the sclerotized tergal plates now greatly isolated on the ovary-distended abdomen.

The astounding numbers of active individuals in a mature colony can account for a surprisingly large amount of damage in a short time. It is possible to hear the termites working in wood if conditions are favorable. They snap their mandibles, especially if disturbed, and by tapping infested wood one may be able to hear clicking sounds.

Unlike the dry-wood termites, no telltale pellets are cast out of the burrows of this species. Hence, extensive damage can be done without any outward signs to warn the property owner. When improperly protected structures are built on heavily infested ground, truly remarkable amounts of severe damage may result in a period of a few months. I have seen parts of walls of a new dwelling hollowed out to mere paint-covered shells in three months' time. The feats of this termite in gaining entrance to buildings sound like "tall tales." They are known to make their way through brick walls, up through hollow-tile construction, through asphalt and asphalt-treated roofing materials, through defective concrete and even through lead sheathing. They will eat through almost any soft material to get at wood. A water hose left lying on the ground has been riddled. When these termites cannot burrow through a substance, they go around or over it by building their covered runways. They cannot go through brick or Portland cement, but they can pass through lime mortar. It is said that the soldiers pour out an acid secretion which dissolves lime mortar, and the grains of loosened sand are removed bit by bit.

The runways in the soil may extend over large areas, and an infestation at one place may have its origin in a nest 150 or 200 feet away. The subterranean burrows have been traced down as deep as 10 feet beneath the surface.

Flights in which thousands of reproductives from single nests take part are common in spring and early summer, and I have seen them as late as November. In Honolulu, major flights begin toward the end of March and extend to July, with the peak usually reached in May and early June. During this period extensive flights may be anticipated in the evenings of warm, sultry days—especially following rains. A heavy, warm rain is apt to bring out early swarms. Flights usually begin at sundown and end before midnight. Occasionally flights are reported in the late afternoon.

After swarming, the males and females pair off and set out to find a suitable place in which to found a nest. The wings are cast and the female leads a peculiar, nervous search for a possible nesting site. She runs about with the male following at her heels with his mouth parts and antennae at the apex of her abdomen. These tandems frequently appear to be single, elongate insects as they run this way and that. If they do not find moist conditions in which to settle down, they die. Specimens collected by me died in less than 24 hours when kept with wood in a dry glass.

The best way to prevent damage by *Coptotermes* is to build termite-resistant structures. With proper attention to structural details, this can be accomplished. Unfortunately, however, too little attention is given the termite problem before damage is apparent. Much money and time are wasted by treating damage after it is extensive, rather than adequately building against it. Unlike the dry-wood termite which is difficult or next to impossible to "build out," structures can be built which are proof against the subterranean termite.

There are several habits and requirements of the subterranean termite which, when interfered with, act decidedly in favor of the property owner and to the detriment of the termites. In the first place, the high humidity requisite to the colony prevents the establishment of subterranean termites in all except restricted situations. Any way that can be devised to eliminate the source of moisture will eliminate the colony. Colonies frequently become established on the roofs of high, reinforced concrete buildings when leaks develop and permit ample quantities of water to become constantly available beneath the roofing where there is some wooden material used in construction. Condensation in the walls, ceilings or attics of commercial buildings such as breweries and cold storage plants may provide favorable places for the establishment of vigorous colonies in the most unexpected places. Small leaks in water or sewer pipes which permit of a constant supply of moisture are also potential sources of colony establishment.

When subterranean termites reach an obstacle in their path, they build characteristic covered runways 5 to 10 mm. broad over the impenetrable obstruction to get to the food supply. By proper construction, it is possible to force the termites to build their runways in the open where they can be detected easily by routine, periodic inspection. Thus, every precaution should be taken to make it impossible for the termites to make a hidden entrance from the ground.

When termites die within the colonial structures, the corpses are devoured by their scavenging fellows. Also, termites not only clean themselves by using their

mouth parts, but they lick one another, and the queen, especially, is given a large amount of attention and is constantly fed and preened by her retinue. These habits make the use of poison dusts unusually effective, because a small amount of poison will frequently kill out an entire colony when applied to the bodies of a relatively few individuals. When Paris green, for example, is dusted into an inhabited gallery, the termites receiving the poison will not only lick themselves and thus become fatally poisoned, but other individuals will lick the dusted specimens, thus spreading the poison, and when the queen is fed she is apt to receive a lethal dose. When the poisoned termites die, the poison consumed by them is not entirely lost, because it is passed on to their fellows when the victims' bodies are consumed.



Figure 104—*Coptotermes formosanus* Shiraki. A stake used at the Bishop Museum for treatment of the subterranean termite as described in the text. Damage such as this may take place in less than six weeks. The top of the stake, which appears uneaten although it is hollowed out, protruded above the ground.

#### RECOMMENDATIONS FOR THE PREVENTION AND CONTROL OF DAMAGE BY *Coptotermes formosanus* IN HAWAII

A knowledge of the habits of subterranean termites will make many methods of control obvious. However, too little attention usually is given the problem by architect, builder and property owner before damage is evident. The time to think about termites and termite control is *before* a new dwelling or other structure is begun. Preventive measures should begin on the building site and blueprint.

##### *A. Suggestions for the Prevention of Attack in New Construction*

1. It is of the utmost importance that all wood and other cellulose materials be removed from the building site. All tree stumps and roots should be taken out. All scrap wood, shavings, large amounts of sawdust, stakes, boards from foundation forms and other such materials should be removed from the premises and not buried under soil fill or left around foundations or scattered about on the ground surface under any part of the building. Such materials left behind by construction workers make ideal sources of food for subterranean termites. All workers on new construction should be made aware that cleanliness is essential, and that all scrap wood and other such debris should be burned or otherwise removed from the premises. A Honolulu institution had a serious termite problem develop because boards used for forms for an extensive concrete retaining wall



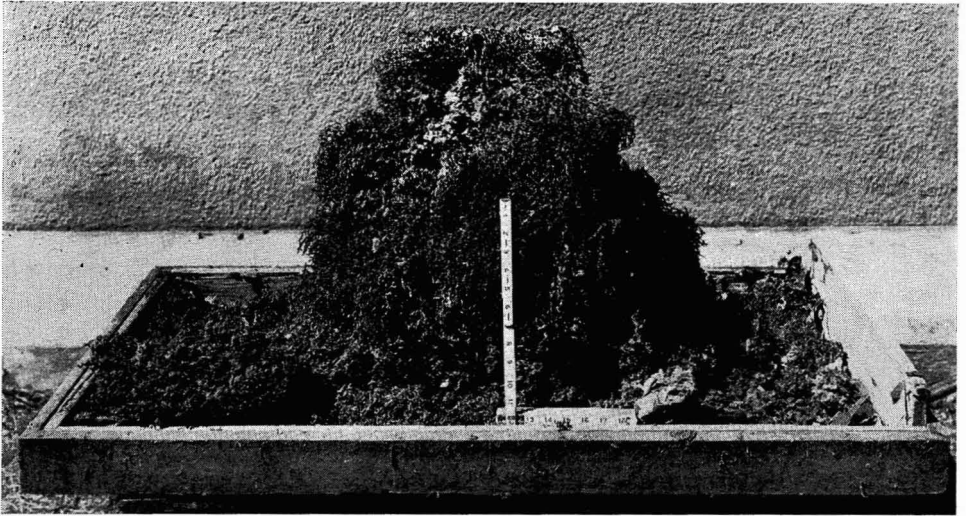


Figure 105—*Coptotermes formosanus* Shiraki. A nest built in a wooden box (size: 22 × 23 × 46 inches) which had rested on wooden planks on the ground in the basement of a building near the Bishop Museum for about a year (1937). The bottom was largely devoured, but the sides and top, although scored on the inside, were largely sound and not greatly eaten internally. The box was more than half filled with 46 pounds of friable nest structure which occupied about 6.5 cubic feet. (See also next figure.)

were left in the soil. This enabled large colonies of termites to build up close to the buildings and provided a major source of infestations over a long period of time. Every effort should be made to eliminate such food sources, because if such materials are unavailable the chances of building infestation are greatly reduced. If ample food supplies are available in the soil, large colonies may build up in the immediate vicinity of new construction and for years serve as a potential source of serious infestation. Although the building itself may be well insulated from the ground, some unforeseen circumstance may arise which will permit termites to gain entrance to the building.

2. If the new construction is built in an area known to be infested by subterranean termites, the soil may be treated with a poisonous chemical. Even if there are no subterranean termites known to occur on the property or near it, soil poisoning is a wise precaution. The United States Department of Agriculture (1942) recommends four principal chemicals for soil treatment which, it is said, can be expected to give at least five years' protection. These materials and suggestions for application are as follows:

Sodium arsenite (soluble in water; extremely poisonous). One gallon of 10 percent solution to every 5 cubic feet of soil treated is suggested by the Department of Agriculture. Randall and Doody (in Kofoed et al., 1934:472-483) consider a 10 percent solution too concentrated for safety. They believe that arsenicals should be avoided, but if they are used, the concentration should be 2 percent or less. They suggest 50 to 100 gallons of 2 percent solution for every 100 square feet of surface

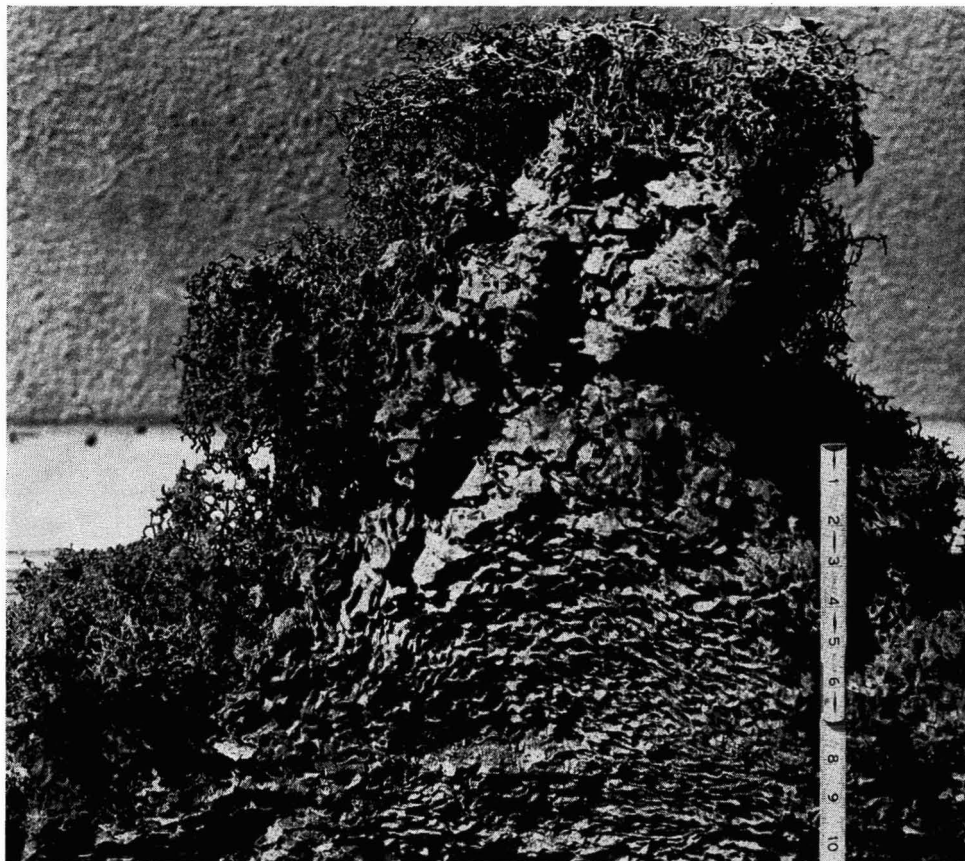


Figure 106—*Coptotermes formosanus* Shiraki. A closer view of the nest shown in the preceding figure cut in half to show the internal structure.

treated. Mr. D. T. Fullaway (personal communication) has had success in Honolulu using about a 3 percent solution of this poison. It should be borne in mind that this is a very dangerous poison, and it should be used only in protected places. No plants will grow on soil treated with it, and the poison remains toxic for years. Moreover, any plants, even very large trees, whose roots are contacted by the solution may be killed outright. Trees as far away as 100 feet from a building being treated have been killed. Many experienced workers do not recommend its use because of the hazards involved. Under certain conditions, the arsenic may be attacked by bacteria with the resultant formation of deadly arsine gas (with a garlic-like odor).

Coal-tar creosote (insoluble in water; a skin and eye irritant). Use 1 part creosote to 3 parts of light fuel oil at the rate of 1 gallon to every 5 cubic feet of soil treated.

Orthodichlorobenzene (insoluble in water; the user should not get the chemical





Figure 107—Half-grown sugarcane ratoons damaged in the soil by *Coptotermes formosanus* Shiraki. This infestation was discovered on the grounds of the Hawaiian Sugar Planters' Association Experiment Station, Honolulu, after the main source of food supply of a colony of the termite was removed and the termites turned to the cane for food. (After Muir, 1917.)

on his skin nor breathe the confined vapors). It is suggested that best results may be obtained if a mixture of 1 part in 3 parts of light fuel oil used at the rate of 1 gallon to every 5 cubic feet of soil treated. This is a more expensive chemical, and it is perhaps best used in combination with coal-tar creosote. The mixture should consist of 1 part coal-tar creosote, 1 part orthodichlorobenzene and 6 parts light fuel oil and be applied as above. This chemical is a basic constituent of certain of the formulas employed by some commercial termite "exterminators."

Pentachlorophenol is used by some workers in a 5 percent solution in a light fuel oil (kerosene and light naphthas will only take up about 3 percent, however, and should not be used without the addition of a more active solvent). This material is also applied at the rate of 1 gallon to every 5 cubic feet of soil treated. The chemical can be purchased ready to use in a 5 percent solution.

McCauley and Flint (1942:23) recommend the following formula: Trichlorobenzene 2 parts and fuel oil 4 parts (by volume) applied at the rate of 3 gallons per 10 cubic feet of soil.

All of these solutions should be applied only beneath buildings where they will not affect shrubbery and are not readily accessible to human beings or pets. Reference should be made to the U. S. Department of Agriculture Farmers' Bulletin 1911 mentioned above, and to Kofoid et al. for detailed information. Great care must be exercised when poisoning the soil.

3. Ample clearance beneath all wooden construction is essential. Homes should be well-elevated from the ground. Every section of a house should be accessible

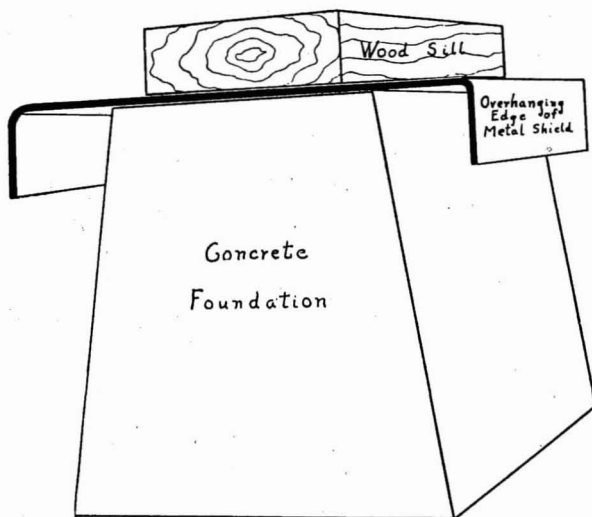


Figure 108—Diagram of cross section of a building foundation structure built to guard against attack by the subterranean termite. Concrete foundations are subject to cracking, and if a continuous metal shield is not laid between the concrete and the wood sill, infestation may occur by way of an undetected crack. The overhanging metal will bring any runways the termites may build over the foundation out into the open where they may be seen. (After Light, 1929:26.)

to permit proper inspection. In most places in Honolulu, a minimum clearance of two feet between floor joists and ground is recommended—and more is desirable. Ample provision should be made to keep the soil under buildings properly drained at all times, and adequate ventilator openings should be provided to insure a good circulation of air. Proper ventilation and drainage will go far toward reducing infestations.

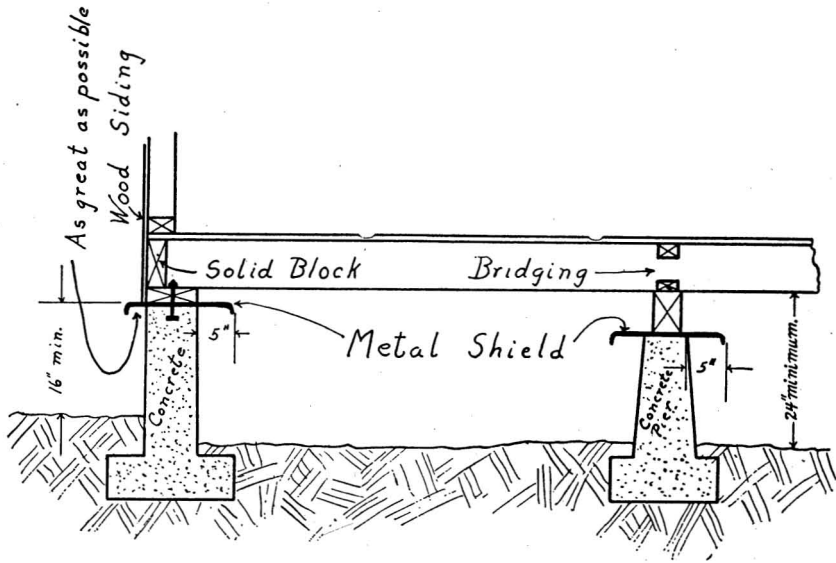


Figure 109—Suggested plan for building against possible attack by the subterranean termite. (After Light, 1929.)

4. The most important aid in the exclusion of termites is proper foundation construction. Unfortunately, much of the so-called termite proofing used in Hawaii is inadequate and improperly installed. Proper protection is not given by putting extensive metal caps on foundations and leaving the joints loose or leaving gaps at the ends. No timber should come in contact with the soil or be placed so near to it that the soil may, by washing in or otherwise, accumulate beneath it so that contact is established at any time after construction. All foundation walls or piers should be made of reinforced concrete. All such concrete foundations should extend at least six inches, preferably 12 inches, above the final possible level of earth or earth fill. All underpinning, sills, etc., should be separated from the foundation by noncorrodible metal shields. If it is necessary to have any wood come into contact with the concrete foundation, then it should be especially pressure-treated poisoned wood. It is advisable to have all underpinning made of pressure-treated poisoned wood. At least, all underpinning should be treated with two heavy coats of hot coal-tar creosote. Such treated wood is in itself not complete protection, however, because termites may extend their runways over it.

When treated wood is cut, the cut ends should receive two coats of hot coal-tar creosote. It is said that the wood treated with other than pressure methods will not give more than five years' protection, and it may become ineffective sooner than five years after treatment, especially in damp situations.

In Hawaii, many foundation walls and piers are constructed of stone and mortar. This type of construction is likely to crack and provide hidden termite entrances. Hollow cement tile and cinder-brick foundations are common but are also subject to cracking. Such foundation structures should be capped by metal shields. The following quotations concerning termite shields are taken from Farmers' Bulletin 1911 (U. S. Dept. Agr. 1942:27-32):

Recent experience has shown that the great majority of shields now in use have been poorly designed and incorrectly installed, giving the owner a false sense of security. The following are the mistakes most commonly observed where shields have been used:

1. Loose joints between sections of metal, often with no evidence of any attempt to solder or otherwise make a tight joint.
2. Improperly cut and soldered corners or angles where walls intersect.
3. Strip shields placed on top of foundations instead of being embedded in or attached to the side of the wall.
4. Anchor-bolt holes cut in bread-pan shields and not sealed with coal-tar pitch.
5. Insufficient clearance between the outer edge of the shield and adjacent woodwork or piping.
6. Shields less than 12 inches above grade line, sometimes even buried by grading operations.
7. Projecting edge of shields battered and bent out of shape, often flattened against piers or foundation wall.
8. Shields installed on sections of a foundation where there was little danger of termites attempting to gain entrance to the building, whereas the points of greatest danger, such as filled porches, were left unprotected.
9. Shields constructed of materials subject to rapid corrosion or to being easily torn or bent out of shape.

It should be remembered that shields, even when properly installed, will give protection only during the period that the metal lasts.

Recent laboratory experimental work with various types of termite shields has shown that no shield developed thus far is absolutely effective in preventing the passage of termites. A properly made and installed shield will, however, force the termites into the open where they can be seen and will thus act as an effective barrier to hidden attack. Termites may construct tubes on the lower surface of a shield, and occasionally one of these tubes will be extended around the edge and up over the upper surface. Frequent inspection for the presence of such tubes, therefore, is essential. If termites do succeed in getting past the shield, it may be necessary to apply a soil poison at the point where the colony is located.

The physical characteristics that appear to be requirements for an effective shield include at least the following:

1. The shield must be constructed of material that is impenetrable to termites. Copper or galvanized iron is most generally used.
2. The surface of the material must be smooth, i.e., slippery or polished, as any roughness makes it easier for termites to attach their tubes to it.
3. The outer edge of the shield should be as thin as possible. A smooth, thin edge makes it difficult for termites to extend their tubes from the lower to the upper surface of the shield and appears to be the most effective feature involved.
4. The projecting edge of the shield should be at least 2 inches from any other object and at least 12 inches above the ground. Termites will often extend their tubes out beyond the edge of the shield. If these free tubes come in contact with a wall, pipe, skirting, or other object that is connected with the structure above, the shield is rendered ineffective.

The bread-pan shield is especially suited for use over masonry walls or piers (stone, tile, brick, or hollow or solid blocks) that are not properly capped with 4 inches of reinforced poured concrete, to prevent termites from working through or between such units and reaching the structural timbers. The following describes their proper installation:

1. On interior walls and piers, extend the metal entirely across the top of the wall or pier and beyond it to project 3 or 4 inches on each side, with the outer portion bent downward at an angle so that the edge of the shield will have a clearance of at least 2 inches from any timber or other object.

2. On exterior foundation walls and piers the projection beyond the outer face of the wall may be reduced, as the wall surface is exposed and any termite activity can be readily detected. The same is true for the inner side of a wall around a full basement. However, the metal should extend far enough beyond the wall to allow a slight downward projection and to be readily inspected. If inspections are impossible or impractical, full projection should be provided, the same as for interior walls and piers.

When the spaces between exterior piers are closed with skirting or lattice work a minimum clearance of 2 inches must be provided around the edge of the shield, 1 inch between the sides of the skirting and the piers, and 2 inches between the lower edge of the skirting and the ground.

In all bread-pan shielding work the shield should be bedded on fresh cement mortar, coal-tar pitch, or coal-tar plastic cement, to seal any openings around the anchor bolts.

Utility pipes should not be neglected, because termites may follow them out of the ground to the building. Inverted funnel shields can be installed on most pipes entering a building and are a wise precaution. Pipes should be suspended from the building rather than placed on piers or wooden blocks on the ground beneath floors. Pipes passing through concrete should have tight flanges around them which are imbedded deeply in the concrete. A small crack will enable the termites to pass through walls or floors.

One particularly vulnerable point of attack is through lattice work or skirting closing off the under parts of houses. All lattice work should be kept clear of the ground and piers. Periodic inspection should be given to see that no soil has come in contact with the skirting (by gardening or other activities).

Shrubby along the sides of houses should be watched carefully, because a branch may provide a perfect route for termites to follow directly into woodwork. Vines growing up beneath houses or along lattice work frequently make access to the buildings possible. Accumulations of humus and dead leaves are not infrequently the entrance routes of subterranean termites. Absolute cleanliness of all areas beneath and immediately surrounding buildings should be the aim of every property owner interested in protecting his premises.

It is of utmost importance that careful routine inspection be made of the entire under parts of houses at least every year and preferably every six months in Hawaii. If your installation is properly constructed, all subterranean termite galleries will be forced into the open where you can see them. This point cannot be over-emphasized.

In the opinion of a number of workers in Hawaii, "termite bait stakes" should be an essential adjunct to termite protection of any dwelling or other building. It has been found that an ordinary pine or fir stake driven into the ground will be attacked in a short time if termites are working in the immediate vicinity. Thus, by discovering where termites are present in the soil, they can be killed out before they do damage. Termite bait stakes can easily be made of any clean, unpainted stock and should be about two inches thick and 18 to 24 inches long. The bottom

end should be pointed to facilitate driving. A deep groove about  $\frac{3}{8}$  or  $\frac{1}{2}$  inch wide should be cut in one side, and into this groove is placed a tight wooden strip so as to leave a hole down the middle of the stake (the same thing can be accomplished by drilling a hole for nearly the entire length of the stake, but that process is more difficult unless a long drill is available). It is important that the lower end of the hole be left closed, otherwise ants may gain entrance to the stakes and drive out the termites. These stakes are driven into the soil at intervals of 6 to 20 feet along the outside of buildings as well as under them, and corks or cotton wads are placed in the tops of the holes. The purpose of the hole is this: when the termites attack the stakes they will soon occupy the hollow (if the top is securely stoppered to exclude the light). An inspection can be made easily and quickly by removing the cork and examining the hole (a flashlight may be necessary). If the termites are in the hole they can be seen easily. When termites are found, a good poison dust should be blown into the interior of the stake. We have found this method effective in controlling termites which had gained entrance to reinforced concrete buildings and stone-walled buildings when it was impossible to locate runways through the walls. If hollow stakes cannot be had, an ordinary stake driven into the ground and periodically pulled out will serve a similar purpose. When termites are found in the stake, the holes in the ground as well as the damaged part of the stake should be dusted and the stake replaced. No dust should be applied to uneaten stakes—only infested stakes are to be treated.

Ehrhorn and other workers in Hawaii have used carbon bisulfide in connection with trap stakes with considerable success. When termites find the stake, it is removed carefully and a quantity of carbon bisulfide is poured into the hole which is then tightly covered. The confined gas will flow back along the termite tunnels and kill all termites with which it comes in contact. If the nest is close enough, the entire colony may be exterminated by the use of a single application—if luck is with you.

Termite bait stakes should be carefully inspected every two or three months. Whenever an infested stake is treated, it should be removed in about a week, the hole filled and a clean stake driven near-by—but not in the hole containing the poison. The author considers this method an excellent one, and surely it is one of the simplest, cheapest and easiest methods of controlling and preventing damage by subterranean termites. It is possible to keep large areas of ground free from termites by increasing the number of stakes used.

### *B. Suggestions for Treating Termite Infestations*

In spite of all precautions taken, termite infestations sometimes do occur in the most unexpected ways and places. Therefore, the property owner should be informed on control of infestations. The most important thing to remember is that the subterranean termites cannot live in dry wood without access to moisture or moist soil. Therefore, if the line of communication between soil and the wood of your building can be broken, then all of the termites in the dry wood will die

and the infestation can be quickly eliminated. In buildings properly constructed against termite damage, it may be relatively easy to discover runways leading from the soil. However, in old structures or in certain buildings such as stores, factories, warehouses and similar buildings where necessity makes construction conform to certain plans, it is often difficult or impossible to find the source of infestation without the expenditure of such large sums of money as to make the attempt impracticable.

If damage is extensive, it will probably be best to call on a commercial firm specializing in such work, because the termites will not only have to be exterminated, but the seriously damaged parts of the building will have to be torn out and replaced.

If *Coptotermes* are found in a dwelling and the source of infestation cannot be ascertained, the woodwork being eaten should be carefully opened and some poison dust such as Paris green, sodium arsenite or sodium fluosilicate blown in at several places with a good dust gun. After treatment, the openings should be plugged. Dusts are not as effective in very damp wood. The finer the dust, the more efficient is its action. One treatment may eliminate the infestation, but subsequent infestation must be watched for. Although a colony may be killed out by dusting, if the soil about the dwelling is heavily infested, another colony may find its way into the same area via the same undiscovered route. Whenever such damage occurs, bait stakes should be set out under and around the dwelling.

Considerable damage may result in factories, warehouses and similar places by termites which have found their way through cracked concrete floors which have been laid directly on the ground, or through cracked walls below the soil surface. If the cracks are easily found they may be filled with coal-tar pitch. However, on occasion more expensive protective methods are essential. It may be necessary to kill out the termites which are nesting beneath extensive floor areas which cannot be adequately controlled by ordinary methods. Holes may be bored at 10-foot intervals over the whole area and a sodium arsenite solution can be pumped in to flood and poison the soil beneath the entire floor area. This has been done with success in Honolulu. On occasion, carbon bisulfide can be poured through similar holes to kill out infestations. When such expensive processes are required, and wherever possible, the holes should be fitted with capped pipes so that another poison application can be made at a future date if necessary.

Many old dwellings can be insulated from the ground by placing all underpinning and other sub-floor wooden structures on solid concrete blocks which have been capped with metal shields and making sure that there is no concealed route whereby termites may enter from the soil. It may be necessary to raise the entire structure off the ground. The whitewashing or white painting of all underpinning will facilitate locating the covered runways should any be constructed—especially in the darker places beneath buildings.

According to information given in Farmers' Bulletin 1911 of the United States Department of Agriculture (1942:37), the common practice of injecting chemicals into installed timbers and woodwork through bored holes has not proved successful.

The bulletin says, "Many attempts have been made to apply chemicals to wood in place in buildings, with the object of controlling existing termite infestations and preventing future damage. No effective control by spraying or fumigation has proved to be possible. It is not considered practical to secure effective penetration by injecting chemicals under pressure through bored holes without boring so many holes that the strength of the timber is seriously weakened. Such methods of control are therefore not recommended." The spraying of chemicals upon wood surfaces has proved to be an unsatisfactory procedure; it is a "snare and delusion."

Before closing this chapter, it is perhaps advisable to caution the property owner to be careful in selecting "termite exterminators" or commercial insect control companies. Much money can be wasted in having poorly trained workers or unreliable firms treat your property. Some workmen can be depended upon to give honest and good service, but the public's lack of knowledge of entomological work in general leaves the way open for exploitation. Some methods and materials used by commercial exterminators have been proved worthless or of little permanent value. However, a reliable firm can do much to aid in the control of insect pests on the premises.



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## Order **EMBIOPTERA** Shipley, 1904

(*embios*, lively; *pteron*, wing)

Embiids, Embiopterans, Webspinners

Elongate slender insects; head large, free and completely exposed, prognathous, broader than the prothorax; antennae larger than the head, multisegmented (about 16–20 segments in our species); compound eyes reniform, well developed, conspicuous, larger in the male than female; ocelli absent; mandibles large, well developed, dentate, larger in the male; maxillary palpi five-segmented; labial palpi three-segmented; four similar membranous wings of nearly equal size and shape present on the male only, folded flat over the pterothorax and abdomen when at rest, with few cross-veins, the insertions of the fore wings widely separated from the insertions of the hind wings; abdomen with ten complete tergites in the female, nine in the male with the tenth asymmetrically divided; with eight complete and fully exposed ventrites, the first and terminal sternites modified or not very evident; female genital opening between sternites eight and nine; male terminalia peculiarly asymmetrical; cerci two-segmented (in our species), asymmetrical in the male; ovipositor wanting; legs with the hind femora enlarged; tarsi three-segmented, the first segment of the anterior pair conspicuously expanded in all stages to hold highly modified spinning glands; claws paired, divergent; hind tarsus with bladder-like protuberances on the soles of the first two segments, middle pair of legs less strongly developed than the others; eggs deposited in groups attached to walls of the tunnels, opercula large and conspicuous; metamorphosis slight, incomplete; nocturnal, soft-bodied insects living in silken tunnels usually beneath objects lying on the ground, under dead bark or in leaf mold.

Only a single representative of this peculiar order occurs in Hawaii, and it is an immigrant.

Fossil Embioptera are known from the Tertiary, and the extinct family Protembiidae has been described from Permian beds. The present geographical distribution of the order is largely tropical, and the north and south limit is between the fortieth and forty-fifth parallels of latitude. There are about 150 species known, and the greatest diversification of the order today appears to be in Africa.

Among all the orders of insects, the Embioptera are unique because of their highly developed tarsal silk-spinning glands which are used to produce great quantities of silk to construct the ramifying galleries in which they live. The only other known insects which have tarsal spinning organs are certain empidid flies, but their silk is used to envelop prey. Embioptera can probably be looked upon as the most efficient of insect silk-makers. All species of the order including both sexes and all instars produce silk.

Mills' (1932:651) description of the spinning habits of the American species *Anisembia texana* (Melander) is worth quoting:

The Embiid's enlarged metatarsi (fore basitarsi) bear a great resemblance to a pair of boxing gloves, and as it swings them about in front of itself in spinning a web, it reminds one of a miniature prize-fighter shadow-boxing. As the feinting continues a fine haze is seen to appear in front of the spinner. Against a light background the fine web is all but invisible and, as the Embiid pushes out on it, it appears to be walking through space. By spinning as it slowly rotates on its long axis, the characteristic silken tunnel is produced. Within this tunnel it seems to pay no attention to gravity, being found as often as not with its ventral side upward. It moves with alacrity both forward and backward in the web. As it moves or hangs in the web, the first and last pairs of legs hook into the web naturally while the middle pair extends over the back, attaching to the portion of the tunnel which is just behind the dorsum; in other words, if the insect is standing in the tunnel with its ventral side down, the middle legs extend upward over the back, hooking into the silk above, but bearing little of the weight of the body. This may account for the comparative reduction in the size of the femora of the middle legs.

All known females are wingless and are little more than sexually mature nymphs. Some genera also contain species in which both males and females are wingless, and other species may have both winged and wingless males. The wings are soft, pliable and tissue-like and are easily crumpled as the males move about in their galleries. Ross (1940) believes that the wings are made rigid for flight by the maintenance of blood pressure in the large radial vein.

The species are usually gregarious and several to many individuals may be found inhabiting a common and extensive system of silken galleries. The eggs are given a primitive sort of attention by the female, who seems to stand guard over them until they hatch, and the young nymphs appear to stay near their mother.

A remarkable and unusual habit of these insects is their ability to run backward as well as forward. When disturbed, they can run backward through their tortuous galleries with surprising speed and evidently with no more difficulty than their forward motion. An interesting anatomical modification has taken place in the enlarged hind femora to make this backward motion possible. Contrary to the usual form of muscle arrangement, the depressor muscle is much more developed than is the levator muscle to the tibia.

### Suborder EUEMBIOPTERA Davis, 1940:677

*Euembia* Tillyard, 1937.

The suborder Protembioptera is known only from Permian fossils, and the suborder Euembioptera contains one fossil and six living families.

### Family OLIGOTOMIDAE Enderlein, 1909

This family is naturally restricted to the Old World, but some of the species have been spread by commerce to both hemispheres. The hemitergites of the tenth tergite of the male are not distinctly separated by a membrane, the radial sector has three branches, the mandibles have apical teeth, and the two-segmented left cercus of the male is not echinulate on the inner side.

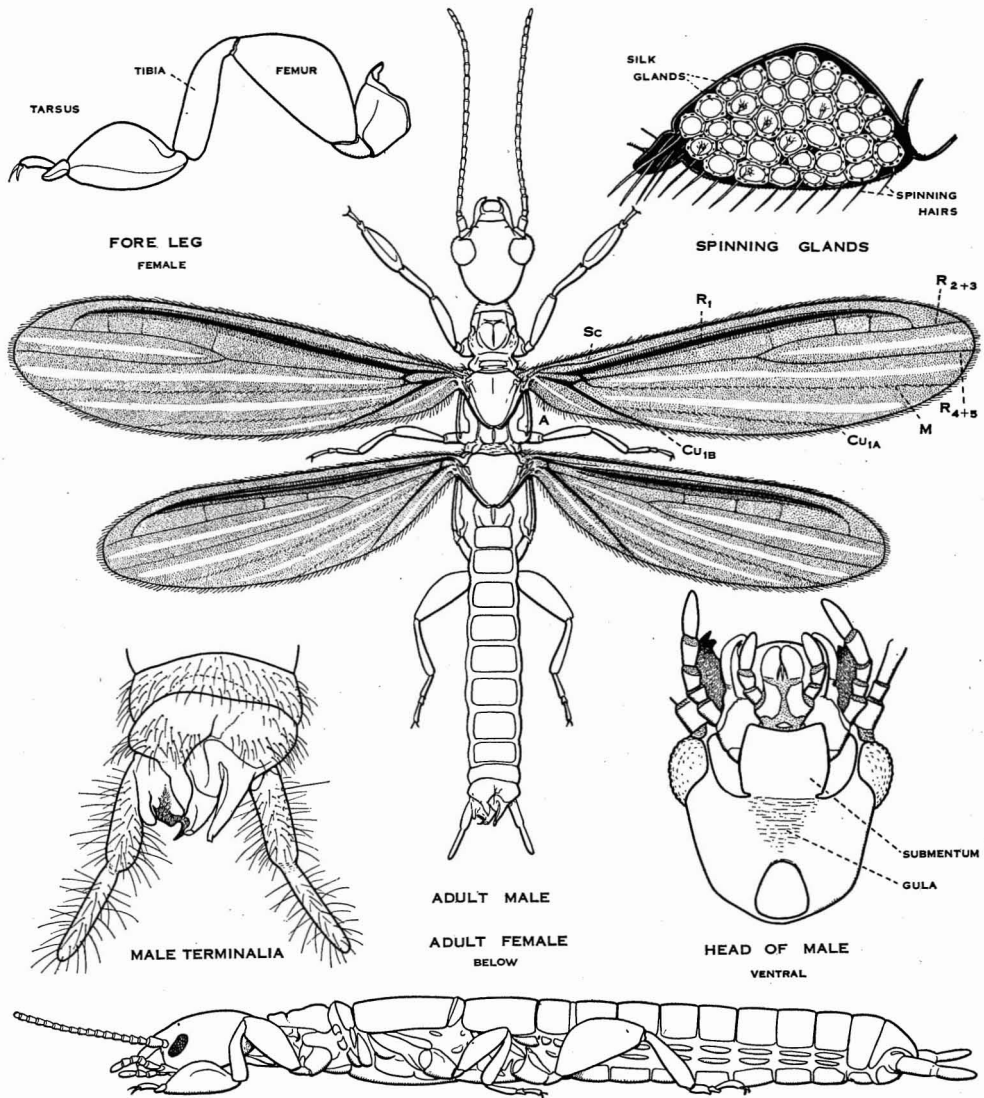


Figure 110—*Oligotoma saundersii* (Westwood). (Plate prepared especially for this volume by E. S. Ross, California Academy of Sciences.)

Genus **OLIGOTOMA** Westwood, 1837:373

This genus is native to the Indo-Australian regions, but some of its members have been widely dispersed artificially through the tropical and subtropical parts of the world. The species found in Hawaii is:

**Oligotoma saundersii** (Westwood) (figs. 110, 111).

*Embia* (subgenus *Oligotoma*) *Saundersii* Westwood, 1837:369, figs. 2, 2a-2f (type from Bengal). Genotype.

*Embia Latreillii* Rambur, 1842:312 (type from Madagascar).

*Oligotoma insularis* McLachlan, 1883:227 (type from Hawaiian Islands).

*Oligotoma Cubana* Hagen, 1885:141 (type from Cuba).

*Oligotoma bramina* Saussure, 1896:352 (type from Bombay).

*Oligotoma hova* Saussure, 1896:354 (type from Madagascar).

*Oligotoma rochai* Navas, 1917:281, fig. 17 (type from Brazil).

*Oligotoma inaequalis* Banks, 1924:421 (type from West Indies).

Davis (1939) and Ross (1940) give figures and extensive discussions of this species and these are referred to the interested student. Davis (1939) gives a long list of the many localities from which the species has been reported.

Kauai, Oahu, Molokai, Maui, Hawaii, Kaula, Nihoa, Necker, Laysan.

Immigrant. Widespread by commerce to many tropical and subtropical parts of the world from Africa to eastern Polynesia and to North and South America. First recorded from the Hawaiian Islands by McLachlan (as *O. insularis*) in 1883.



Figure 111—*Oligotoma saundersii* (Westwood). Male, left; female, right; not to same scale. (Photograph of female supplied by E. S. Ross.)

Parasite: *Mystrocnemis vagabundus* (Bridwell) (Hymenoptera: Sclerogibbidae).

This species is common in Hawaii and is most abundant in the drier lowlands. It has been found in dry areas up to 3,000 feet, however.

It can be discovered in its extensive webbings beneath old boards and other such articles thrown out on grass or leaves especially, under dead bark, under stones, particularly if they are on decaying vegetation, in dead matted vegetation, in hollows in branches, in ground litter and in similar situations. Its food consists of dead vegetable matter, and perhaps it eats fungi also. I have kept the species alive in damp leaf mold in the laboratory for many months. The males are attracted to light. Ross (1940) gives an ample redescription of the species and a detailed bibliography. Perkins (1897) and Kershaw (1914) give notes on the development.

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## Order **DERMAPTERA** Leach, 1815

(*derma*, skin; *pteron*, wing)

Earwigs; Hawaiian name: "lo"

Body elongate, depressed, well sclerotized, leathery; head large, exposed, subcordate, prognathous; mandibles large, masticatory, dentate; maxillary palpi five-segmented; labial palpi three-segmented; antennae elongate, filiform, multisegmented, longer than the head and prothorax, with 10 to about 50 segments; compound eyes well developed; ocelli absent; wings present or absent, when present the fore pair reduced to veinless, abbreviated, leathery tegmina shorter than the abdomen and similar in appearance to the elytra of staphylinid beetles; hind wings peculiarly developed, semicircular, the vanal area greatly enlarged, with modified, radiating veins arising from rather extensive sclerotized anterior and basal areas, folding fanwise longitudinally and twice transversely for storage beneath the tegmina; legs ambulatorial, widely separated; tarsi three-segmented, claws paired, free, empodium present or absent; abdomen largely exposed, telescopic, 11-segmented, first and last tergites modified, concealed or indistinct, male with nine

The diagram illustrates the dorsal view of an earwig, a long, segmented insect. The head is at the top, with long antennae extending outwards. The thorax is the middle section, featuring a pronotum, elytra (wing covers), and legs. The abdomen is the long, segmented posterior part, ending in a pair of forceps (pincers). Various anatomical features are labeled with lines pointing to them:

- Head:** Antenna, Frons, Frontal suture, Occiput, Median suture.
- Pronotum:** Prozona, Suture, Metazona, Shoulder, Scutellum.
- Anal angle:** Sutural margin, Costal margin.
- Elytra:** Posterior margin.
- Wings:** Posterior femur.
- Glandular folds or stink-glands:** Posterior tibia.
- Abdomen:** Posterior tarsus.
- First tarsal segment:** Last dorsal segment.
- Second tarsal segment:** Pygidium.
- Third tarsal segment:** Forceps.
- Pulvillus:**
- Claws:**

Figure 112—Diagram of dorsal aspect of an earwig. (After Burr, 1910.)

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tergites visible, female with seven; males with eight visible ventrites, females with six; cerci unusually large and conspicuous, modified in the adult into large, strong, conspicuous, heavily sclerotized, unsegmented forceps, often armed with teeth; ovipositor wanting; metamorphosis slight; eggs of most species laid in batches in nests usually in the soil or under objects on the ground or in protected places in the ground or in vegetation or under bark or in debris; four to six molts; mostly nocturnal, omnivorous or mostly carnivorous dwellers of moist places and easily recognized because of their conspicuous forceps, short tegmina, unconventional wings and exposed abdomen.

Fossil Dermaptera are known from as far back as the Jurassic. Today the order is represented by approximately 1,000 living species, most of which are tropical insects.

Imms (1934:252) says, "The term 'earwig' possibly took its origin from the fact that these insects have been known to use the human ear for purposes of concealment; on the other hand it has been suggested that the word is a corruption of 'earwing' in allusion to the form of the hind-wings."

The forceps are used for various purposes by different species. Most species use them in capturing or holding insect prey and for defense and fighting. Some are reported to use them during copulation, or to aid in folding the wings; some

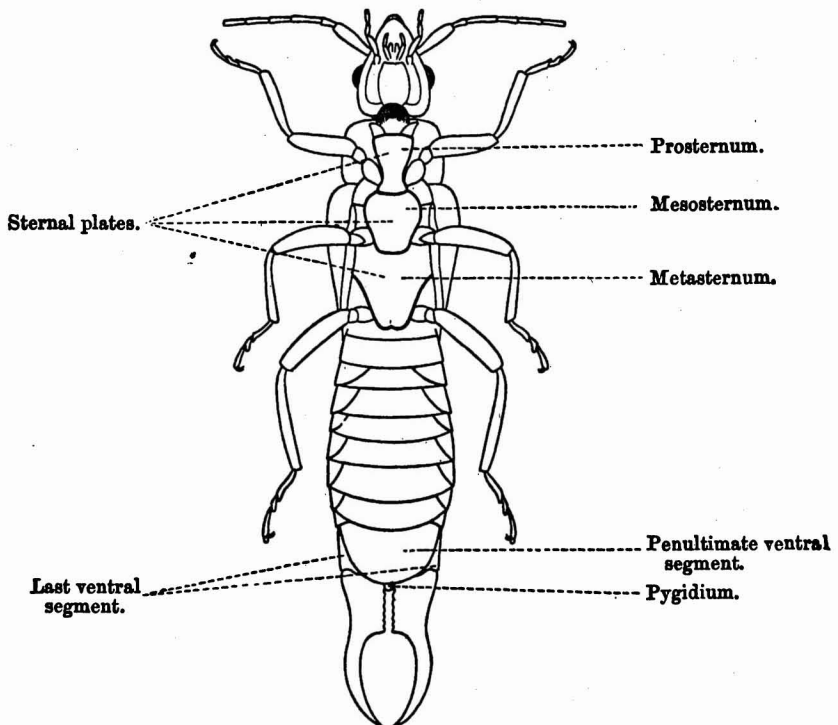


Figure 113—Diagram of ventral aspect of an earwig. (After Burr, 1910.)

observers report that certain species do not use their forceps for copulation or for folding their wings. Some species can pinch hard enough to draw blood from a finger. Most observers report that the movements of the insects and the action of their forceps in capturing prey are "lightning-like."

One of the unusual habits of the earwigs is the care given the eggs and young by the female. After the eggs are deposited, the mother earwig crouches over them in a manner suggestive of a setting hen and, after the eggs have hatched, cares for the young until they are ready to forage for themselves.

The peculiarly formed hind wings of earwigs are unlike those of any other group of insects (see fig. 117).

Although there have been several species described from Hawaii, and some species are known only from the islands, it appears that all are immigrant species, and that Hawaii is without an endemic earwig fauna.

The species found in Hawaii are considered generally as beneficial insects, but some species found elsewhere are pests of economic importance.

The order is a taxonomically difficult one, and the student may have difficulty identifying his material. The variation within the species is great and confusing.

The characters used in the keys in this section apply to the species found in Hawaii only and may not be applicable for the separation of other genera and species. I have attempted to use characters most easily seen by the non-specialist and student.

TABULAR ANALYSIS OF THE HAWAIIAN DERMAPTERA

FAMILY	GENERA	ENDEMIC GENERA	NON- ENDEMIC GENERA	SPECIES	ENDEMIC SPECIES	ADVENTIVE SPECIES
Labiduridae	3	0	3	4	0	4
Labiidae	3	0	3	5	0	5
Chelisochidae	2	0	2	2	0	2
Totals	8	0	8	11	0	11

Fauna 100 percent adventive.

Average number of species per genus: 1.3.

### Suborder FORFICULINA Newman, 1834

The only other suborder is the Arixenina, which includes aberrant insects which are ectoparasitic on, or otherwise associated with, bats. None of these peculiar insects is found in Hawaii.

#### KEY TO THE FAMILIES OF DERMAPTERA FOUND IN HAWAII

1. Second tarsal segment produced into a conspicuous lobe under, and extending for about half-way beneath, the third segment (examine from the side).....**Chelisochidae.**
- Second tarsal segment either simple or bilobed but not produced beneath the third ..... 2

2. Pygidium vertical and concealed from view or almost concealed from directly above; antennal segments four to six, inclusive, shorter than, or at most as long as, first plus second, segment six less than twice as long as broad (be sure to measure across the broadest side).....**Labiduridae.**
- Pygidium visible from above, usually broadly exposed; antennal segments four to six inclusive much longer than first plus second, six always twice or more than twice as long as broad .....**Labiidae.**

### Family LABIDURIDAE Verhoeff, 1902

#### KEY TO THE SUBFAMILIES FOUND IN HAWAII

1. Posterior margin of the mesosternum conspicuously arcuate; wings and elytra normally absent in our species.....**Psalinae.**
2. Posterior margin of the mesosternum subtruncate; wings and elytra present in our species.....**Labidurinae.**

#### Subfamily PSALINAE

#### KEY TO THE GENERA AND SPECIES FOUND IN HAWAII

1. First antennal segment about as long, or as long, as distance between antennal sockets; excluding caudal tergite, all other tergites densely clothed with short, prostrate, conspicuous hairs borne from very dense, subconfluent punctures, tergites obviously dull under magnification.....**Anisolabis perkinsi** Burr.
- First antennal segment distinctly shorter than distance between antennae; the above-mentioned tergites shiny or comparatively so and with short, inconspicuous hairs..... 2
2. Femora all yellow, without a fuscous spot or ring about middle; length, excluding forceps, 15-16 mm.; forceps over 4 mm. long.....**Anisolabis eteronoma** Borelli.
- Femora usually with a fuscous spot or band about middle; length, excluding forceps, not over 14 mm., usually much smaller; forceps less than 3 mm. long.....**Euborellia annulipes** (Lucas).

Note: these species are extremely variable and considerable difficulty may be had in identifying some individuals. *A. perkinsi* and *A. eteronoma* are larger and have longer forceps than *E. annulipes*.

#### Genus ANISOLABIS Fieber, 1853

**Anisolabis eteronoma** Borelli (fig. 114).

*Anisolabis eteronoma* Borelli, 1909:315.

*Anisolabis littorea* (White) of Bormans, 1882:339; not *Forficula littorea* White, 1874.

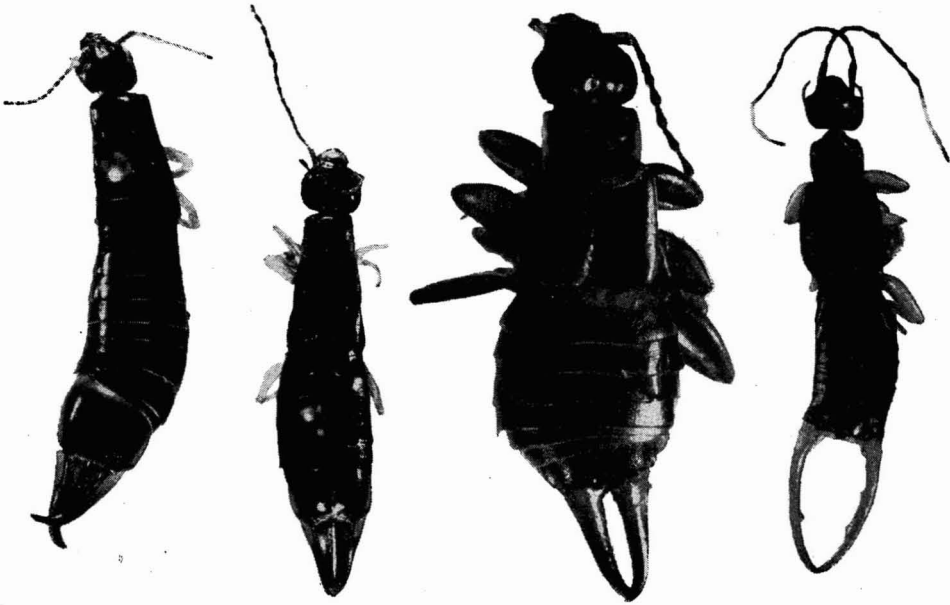


Figure 114—Some earwigs. From left to right, *Anisolabis eteronoma* Borelli; *Euborellia annulipes* (Lucas); *Prolabia arachidis* (Yersin); *Sparattina nigrorufa* (Burr). (Not to same scale.)

Misnamed *Anisolabis maritima* (Géné) and *Anisolabis pacifica* Erichson in some Hawaiian literature.

Hebard, 1922:309, notes and discussion.

Kauai, Oahu, Molokai, Lanai, Maui, Hawaii (type from Hilo), Gardner Pinnacles, Pearl and Hermes Reef, French Frigate Shoal, Laysan.

Immigrant, but source undetermined. First recorded from the Hawaiian Islands by Bormans in 1882.

Habit: widespread; common in vegetable trash, rotten logs, rotting banana stems, under bark, under stones, in the soil and in similar situations in both the lowlands and mountains.

***Anisolabis perkinsi* Burr (fig. 115, a).**

*Anisolabis perkinsi* Burr, 1910:178.

*Anisolabis xenia* Kirby, misidentification by Burr, 1911:448; also evidently called *Anisolabis pacifica* Erichson in some Hawaiian literature.

Hebard, 1922:310, descriptive notes, pl. 26, figs. 1 and 2.

Kauai (type locality), Oahu, Maui, Hawaii.

Immigrant, but source unknown.

Evidently a mountain species. The dense hairs of the abdomen serve to distinguish it from *A. eteronoma*, but it appears to be very closely allied to that species.

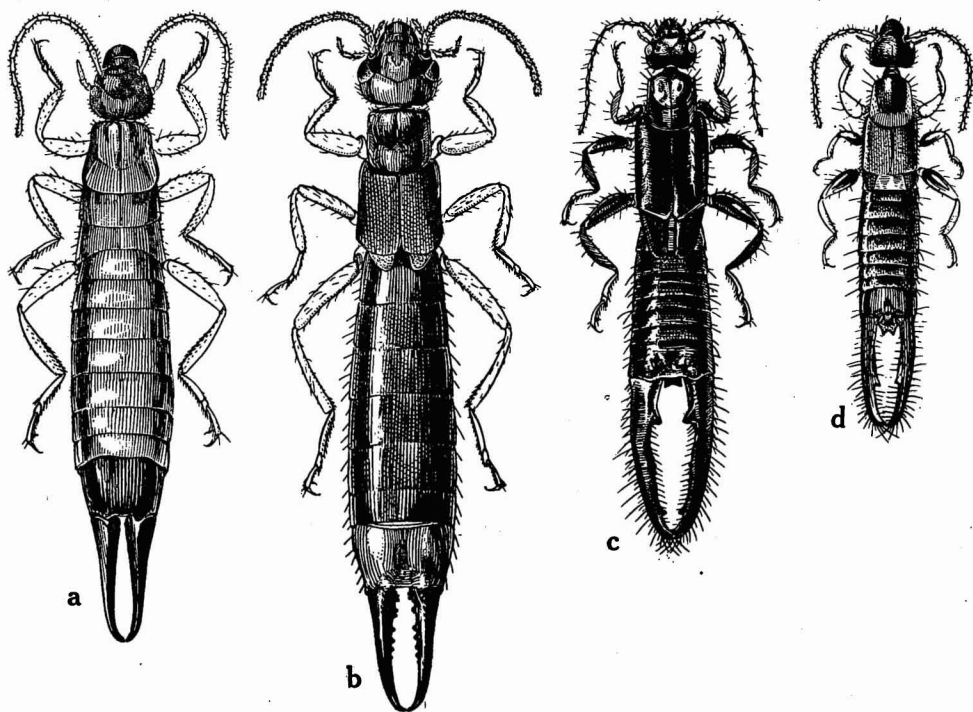


Figure 115—Some earwigs. a, *Anisulabius perkinsi* Burr; b, *Labidura riparia* (Pallas); c, *Sphingolabis hawaiiensis* (Bormans); d, *Labia dubronyi* Hebard. (Abernathy drawings; a and b to same scale, c and d to different scales.)

Some of Blackburn's early collections (about 1880 ?) are labeled *Anisulabius littorea*. One of Blackburn's female examples is 28 mm. long including the forceps.

### Genus **EUBORELLIA** Burr, 1910

*Borellia* Burr, 1909.

The generic differences between this genus and *Anisulabius* are certainly not very obvious. The genus is said to be based upon characters found in the male genitalia.

**Euborellia annulipes** (Lucas) (figs. 114; 117, c-d).

*Forficesila annulipes* Lucas, 1847:lxix (type from Paris).

*Anisulabius aporonoma* Borelli, 1909:317 (type from Honolulu).

The synonymy of this species is extensive; see Burr, 1910:84, fig. 24.

The spotted- or ring-legged earwig.

Kauai, Oahu, Molokai, Lanai, Maui, Hawaii, Nihoa, Necker, French Frigate Shoal, Pearl and Hermes Reef, Midway.

Immigrant. Almost cosmopolitan. First recorded from the Hawaiian Islands by Borelli in 1909, but here earlier.

This is one of the commonest, if not the commonest, species of earwig in Hawaii and is widespread in the lowlands and uplands. It is extremely variable. Although it is normally without wings or elytra, a rare individual is occasionally discovered which has the elytra developed. Some specimens have the dark femoral bands obsolete. Although omnivorous, it was recorded as feeding almost exclusively on the sugarcane leafhopper during the early years of heavy damage by that pest. The eggs are laid under stones and trash, and the earwig may be found hiding during the day at the bases of leaves of sugarcane and *Freycinetia*, in trash and similar places. It carries the larvae of the poultry nematode *Subulura brumpti* (Alicata, 1939). Terry (1905:165) has published some anatomical notes.

Some specimens in Perkins' collection at the Bishop Museum are labeled as being very numerous in cases of Fijian plants inspected at Honolulu.

#### Subfamily LABIDURINAE

#### Genus **LABIDURA** Leach, 1815

##### **Labidura riparia** (Pallas) (fig. 115, b).

*Forficula riparia* Pallas, 1773:727.

*Forficesila icterica* Serville, Histoire Naturelle des Insects Orthoptères, Suites à Buffon, Paris, 1839:25 (I have not checked this reference).

For a detailed discussion and an introduction to the extensive and involved synonymy, see Burr, 1910:99-102, figs. 33, 34. Genotype of *Labidura*.

Kauai, Oahu, Molokai, Maui.

Immigrant. Cosmopolitan. First noted on Oahu soon after 1900.

This is our largest earwig; some specimens are about 30 mm. long, including the forceps.

Found beneath trash, under stones and similar places from the lowlands to at least 4,000 feet.

#### Family LABIIDAE Burr, 1909

#### Subfamily LABIINAE

#### KEY TO THE GENERA FOUND IN HAWAII

1. Wings wanting or aborted; pronotum and elytra without conspicuous discal hairs or setae; fifth antennal segment more than one-half as broad as long.....**Prolabia** Burr.
- Wings developed; pronotum and elytra either with sparse but distinct, long, erect hairs or dense short, conspicuous prostrate hairs over all; fifth antennal segment less than one-half as broad as long..... 2

2. Hair on pronotum, elytra and exposed parts of wings dense, conspicuous, prostrate or subprostrate, partially obscuring derm which, because of dense hair-bearing punctures, is dull ..... **Labia** Leach.  
 Hair on pronotum, elytra and exposed parts of wings sparse, widely spaced, long and erect, leaving derm fully exposed and shiny ..... **Sphingolabis** Bormans.

### Genus **PROLABIA** Burr, 1911

**Prolabia arachidis** (Yersin) (fig. 114).

*Forficula arachidis* Yersin, 1860:509, pl. 10, figs. 33-35.

See Burr, 1910:123, for detailed synonymy and fig. 82.

Oahu.

Immigrant. Cosmopolitan. First collected in Honolulu in 1914 by Swezey. There are few recorded captures of this species in Honolulu, and it is not certain that it is definitely established.

### Genus **LABIA** Leach, 1815

#### KEY TO THE SPECIES FOUND IN HAWAII

1. Males ..... 2  
    Females ..... 4
- 2(1). Forceps strongly arcuate, C-shaped, when closed leaving an almost O-shaped space between them .....  
       ..... **Labia curvicauda** (Motschulsky).  
    Forceps not so shaped, straighter ..... 3
- 3(2). Pygidium not visible when viewed from directly beneath (that is, not projecting beyond apex of last ventrite), its greatest expansion dorsal and nearly on same level as tops of forceps; wings extending beyond second visible tergite; pronotum broader than long .....  
       ..... **Labia pilicornis** (Motschulsky).  
    Pygidium broadly and conspicuously exposed when viewed from beneath, its greatest expansion ventral and on a level beneath that of ventral faces of forceps; wings not or hardly projecting beyond first visible tergite; pronotum as long as broad ..... **Labia dubronyi** Hebard.
- 4(1). Forceps with a dorsal and ventral row of teeth on inner sides ..... **Labia dubronyi** Hebard.  
    Forceps with at most a single row of minute denticles on inner sides ..... 5
- 5(4). Pronotum about same color as elytra, dark brown, broader than long; inner surfaces of forceps vertical just behind pygidium and then dorso-laterally oblique (when closed distinctly separated just behind pygidium) .....  
       ..... **Labia pilicornis** (Motschulsky).



Pronotum distinctly yellowish and obviously paler than elytra to naked eye, fully as long as broad; inner surfaces of forceps conspicuously dorso-ventrally oblique from pygidium caudad (when closed their inner edges touch at base).....***Labia curvicauda*** (Motschulsky).

***Labia curvicauda*** (Motschulsky) (fig. 116).

*Forficesila curvicauda* Motschulsky, 1863:2, pl. 2, fig. 1.

See Burr, 1910:118, for synonymy and fig. 38.

Kauai, Oahu.

Immigrant. Widespread in tropical and subtropical regions. First found by Swezey at Honolulu in 1915.

***Labia dubronyi*** Hebard (fig. 115, d; 116).

*Labia dubronyi* Hebard, 1922:318, pl. 26, figs. 6-7.

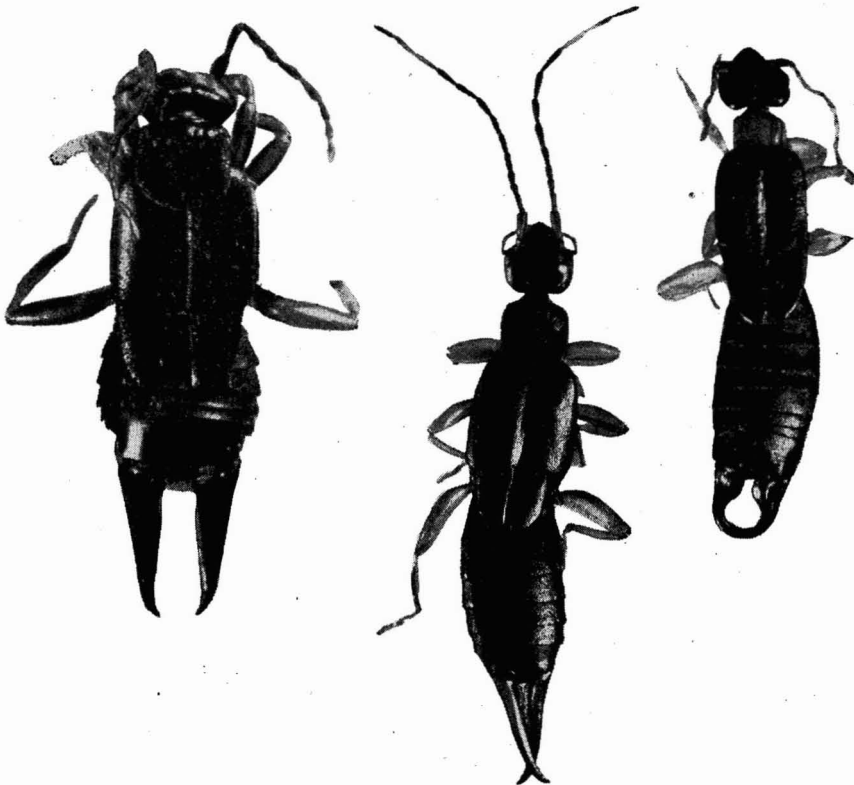


Figure 116—*Labia pilicornis* (Motschulsky), left; *Labia dubronyi* Hebard, center; *Labia curvicauda* (Motschulsky), right. (Not to same scale.)

Misidentified (?) by Bormans, 1882:340, 3 figs., as *Labia pygidiata* Dubrony, 1879.

Burr, 1910, pl. 5, fig. 41 (as *L. pygidiata*).

*Labia swezeyi* Hebard, 1932:31, fig. 1 (type from Mount Kaala, Oahu). New synonym.

Kauai, Oahu, Molokai, Maui, Hawaii (type from Hauula).

Immigrant. Known also from the Marquesas. First recorded by Bormans in 1882 from Oahu.

After examining a large series of individuals, I feel that *swezeyi* is based upon individual variants and is not a good species. The specimens at hand show a large amount of variation of the characters used by Hebard to separate his two "species." Hebard considers this species distinct from *Labia pygidiata* Dubrony with which other authors have associated Hawaiian specimens.

This species seems to be a forest insect only. It has been found under bark of various trees such as *Pisonia*, *Sideroxylon*, *Wikstroemia*, *Pipturus*, *Aleurites moluccana*, in rotting *Charpentiera* and banana stems, in rotting *Alectryon* fruits, and in *Astelia* and *Lobelia*.

***Labia pilicornis*** (Motschulsky) (fig. 116).

*Forficula pilicornis* Motschulsky, 1863:2.

Burr, 1910:120, fig. 40. Hebard, 1922:316, pl. 26, figs. 3, 4; redescription.

Oahu, Hawaii.

Immigrant. Widespread in the Indo-Pacific regions. First found on Oahu by Swezey in 1914.

Recorded from behind leaf sheaths of sugarcane and on avocado.

### Genus **SPHINGOLABIS** Bormans, 1883

***Sphingolabis hawaiiensis*** (Bormans) (fig. 115, c).

*Forficula hawaiiensis* Bormans, 1882:341, 3 figs.

Kauai, Oahu, Hawaii (type locality).

Immigrant. Widespread in the Pacific from Malaya eastward. Described from Hawaii.

This is the largest (about 10–20 mm. long including the forceps) and apparently the most common member of the Labiidae found in Hawaii, but little is known regarding its habits here. It may be found in rotten banana stems and similar situations. It rather closely resembles *Chelisoches morio* and might be confused with that species. However, in addition to the differences between the tarsi, this species can be distinguished offhand because it has conspicuously hairy forceps whereas those of *Chelisoches morio* are bare.

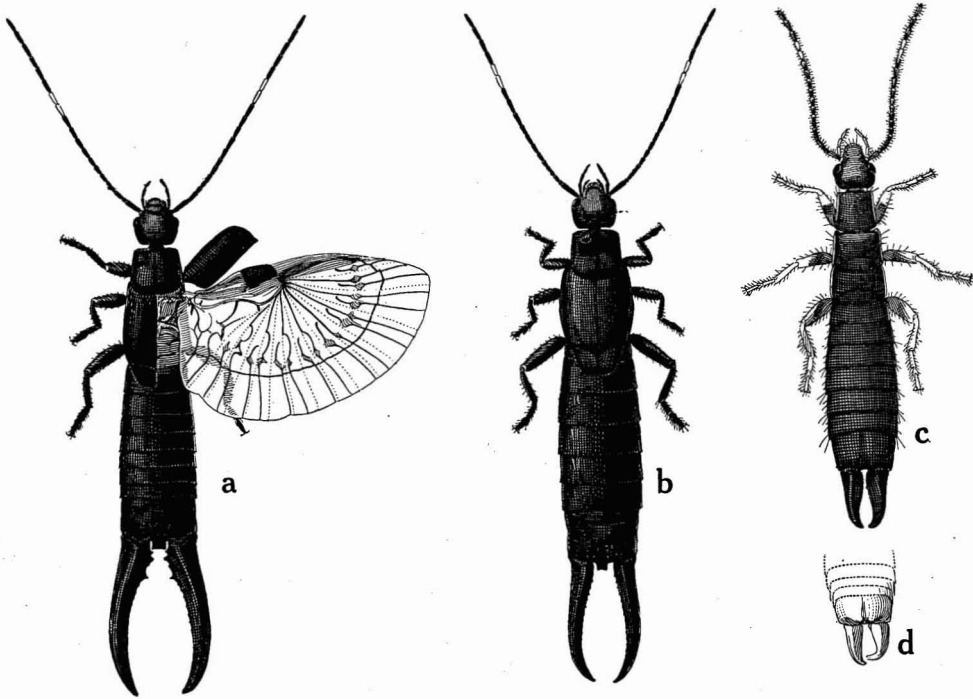


Figure 117—Two species of earwigs: a, b, male and female *Chelisoches morio* (Fabricius); c, *Euborellia annulipes* (Lucas), female, and apex of male abdomen at d. (From the original drawings for Terry, 1905.)

### Family CHELISOCHIDAE Burr, 1907

#### Subfamily CHELISOCHINAE

#### KEY TO THE GENERA AND SPECIES FOUND IN HAWAII

1. Forceps shiny black, with at most a few hairs near their bases; pronotum, elytra and exposed parts of wings without hair (do not confuse the scattered marginal setae with hair); femora and tibiae shiny black. . . . *Chelisoches morio* (Fabricius).
2. Forceps yellow, conspicuously clothed with long, fine hair from base to apex; pronotum, elytra and exposed parts of wings entirely and densely clothed with conspicuous hair; legs yellow . . . . . *Sparattina nigrorufa* (Burr).

#### Genus **CHELISOCHES** Scudder, 1876

*Lobophora* Serville, 1838, preoccupied.

***Chelisoches morio*** (Fabricius) (figs. 117, a-b; 118, a-f; 119, A-B).

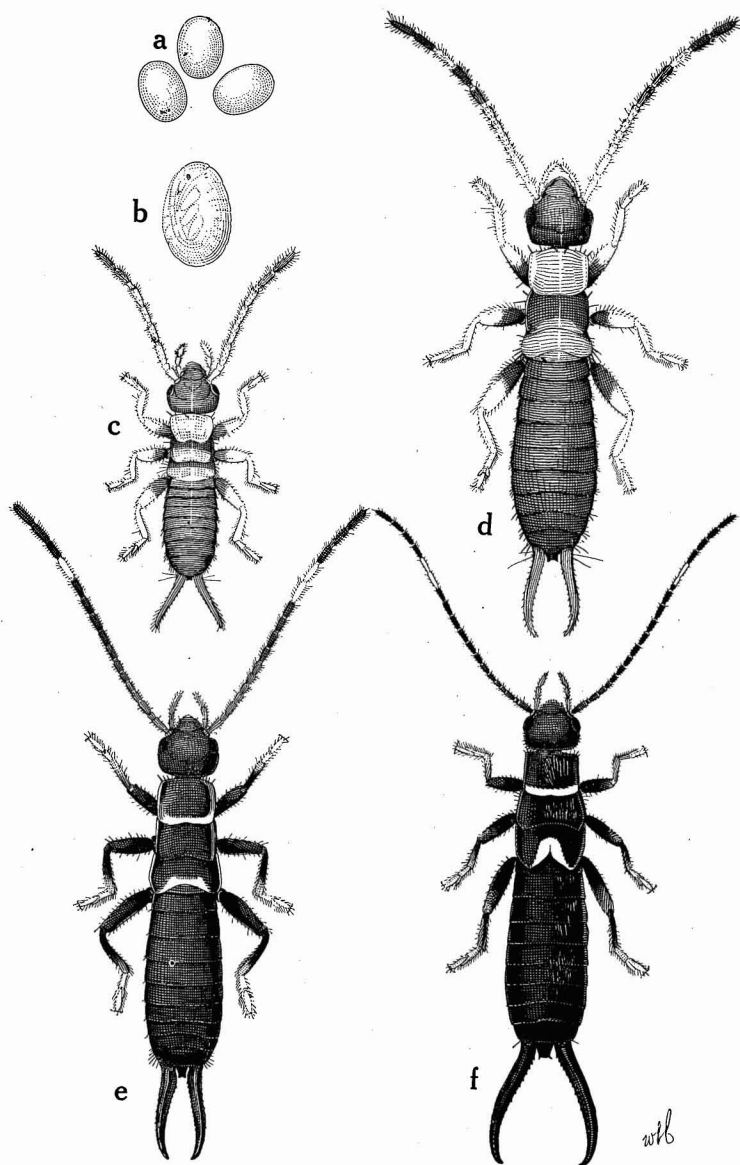


Figure 118—*Chelisoches morio* (Fabricius), immature stages: a, eggs; b, embryo in ovum; c, first instar nymph; d, second instar; e, third instar; f, fourth instar. (From the original drawings for Terry, 1905.)

*Forficula morio* Fabricius, 1775:270.

For extensive synonymy see Burr, 1910:135, and figure. Genotype of *Chelisoches*.

The black earwig.

Kauai, Oahu, Molokai, Maui, Lanai, Hawaii.

Immigrant. This Oriental species has been spread over most of the world by commerce. It is widespread on most of the high Polynesian islands. It was first found in the islands by some of the early voyagers to Hawaii.

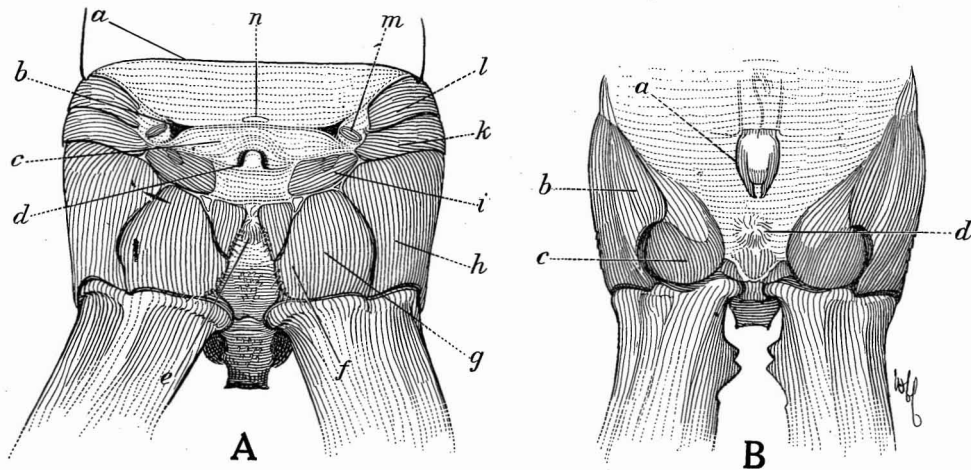


Figure 119—Details of genitalia of *Chelisoches morio* (Fabricius). **A**, Underside of apex of abdomen of female with seventh sternite removed to expose parts: *a*, cut edge of seventh sternite; *b*, sclerotized anterior angle of eighth sternite; *c*, membranous area representing eighth sternite; *d*, posterior chitinated emargination of eighth sternite; *e*, anus; *f*, articular part of tenth sternite (the articulation allows for the free passage of the feces); *g*, *h*, tenth sternite; *i*, thin sclerotized plate of ninth sternite; *j*, omitted by artist; *k*, ninth sternite; *l*, eighth sternite; *m*, seventh abdominal spiracle; *n*, genital opening. **B**, Underside of apex of abdomen of male with ninth sternite removed to expose parts: *a*, aedeagus; *b*, *c*, tenth tergite; *d*, anus. (From original drawings for Terry, 1905.)

This is one of the commonest earwigs found in Hawaii. It is readily recognized by its large size (up to more than 20 mm. including the forceps), shiny black derm and by the two pale antennal segments which are conspicuous in the living insect. It is common at the bases of leaves of such plants as *Cordyline* ("ti"), *Canna*, *Freyinetia* ("ieie"), *Dracaena* and sugarcane. Perkins (1913:ccxii) says that he saw it feeding on caterpillars and sugarcane leafhoppers and that "They often seize and hold their prey in their forceps." Perkins also recorded that the species fed upon the fruits of *Freyinetia* in the mountains. Terry (1905:164-171) prepared a detailed and excellent report on its anatomy, development and life history. He says:

It is an extremely active species, especially during the larval period, and appears to be diurnal, running over the leaves in search of insect food during the hottest part of the day. The adults will readily take to flight, the unfolding of the wings being a very rapid process and quite independent of the forceps, the writer never having seen them used either to assist in the folding or unfolding process. Wet localities seem to suit it best, since it abounds in the moist mountain ridges and valleys, and also in many of the elevated and wetter plantations. It is scarce in the dry and irrigated cane areas. Its predatory habits on leaf-hoppers have been observed by several people. Young hoppers are seized and devoured without the aid of the forceps, but these organs frequently assist in holding an adult hopper whilst it is eaten at leisure. An examination of numerous crops invariably revealed only insect remains, often entirely leaf-hopper. Those bred in captivity showed during all instars a marked preference for insect diet.

The eggs are deposited in a heap usually in the leaf sheaths of various large-leaved succulent plants such as *Canna* and sugar-cane, and are placed sufficiently far down to afford ample protection from the sun or enemies, the mother keeping continuous guard during the incubation period and for several days after the hatching of the young. She is most assiduous in her attentions to her ova, removing them carefully with the mandibles and palpi and constantly rearranging the batch...not infrequently however if disturbed, she will devour the entire lot. These batches consist of from about 40 to 60 eggs, the average number being about 45. Upon deposition they are of an ivory whiteness and broadly oval, measuring about 1 mm.  $\times$  0.75 mm.

There are five molts after hatching and the insect reaches adulthood in its sixth instar. The following data are derived from Terry's work: eggs hatch in 6 days, first molt on 12th day, second molt on 23rd day, third molt on 36th day, fourth molt and adult on 56th day. The number of generations in a year has not been ascertained. Terry (1906) also wrote an account of the development of the antennal segments of this species.

### Genus *SPARATTINA* Verhoeff, 1902

*Sparattina nigrorufa* (Burr) (fig. 114).

*Spongiphora nigrorufa* Burr, 1902:4, pl. 20, fig. 3.

*Hamaxas nigrorufa* (Burr) Burr, 1915:118. Borelli, 1928:7.

*Sparattina nigrorufa* (Burr) Hebard, 1922:323, pl. 26, figs. 8, 9.

Hawaii.

Immigrant. Widespread in the Pacific. The earliest record I have of this species in Hawaii is from two male examples collected by Perkins at Hilo, Hawaii, in June, 1903, and from a single female taken by Blackburn on Hawaii (a note on this specimen written by Perkins says that it was taken about 1880). These three examples are in Perkins' collection at the Bishop Museum and their identity was unknown to Perkins.

This species has been found only on the island of Hawaii and nothing is known of its habits.

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## Order ZORAPTERA Silvestri, 1913

(*zoros*, pure; *aptera*, wingless)

### Zorapterans

Body soft; head large, fully exposed, hypognathous, trophi orthopteroid; mandibles large, dentate, masticatory; maxillary palpi five-segmented; labial palpi three-segmented; antennae longer than the head and prothorax, moniliform or filiform, nine-segmented (eight-segmented in nymphs); compound eyes and three ocelli present in winged forms or nymphs of winged forms, absent or obsolete in wingless forms. Thorax with the metathorax smallest, mesothorax intermediate, and prothorax largest; legs simple, cursorial; tarsi two-segmented, first segment much smaller than second; wings present or absent, slender when present, fore pair largest, folded back along abdomen at rest, bases petiolate, deciduous, venation greatly reduced, cross-veins few or absent, only one longitudinal vein in hind wing. Abdomen 10-segmented, the two caudal segments reduced; cerci present, not segmented; ovipositor absent; male with ninth ventrite absent, genitalia either symmetrical or asymmetrical. Metamorphosis simple; eggs laid free; small nocturnal insects, fungivorous or scavengers on dead arthropods (or carnivorous ?), living in colonies beneath dead bark or in dead wood.

This small order contains a single genus of about 20 species. None has been found fossil. The described species are known from both North and South America, Africa and the Indo-Pacific regions; the group is predominantly a tropical and subtropical one.

Some workers consider the Zoraptera to be a suborder of the Corrodentia, but there appears sufficient reason for considering the group distinct. There are a number of morphological features which are similar to those of the Orthoptera and others suggestive of the Isoptera, but, on the whole, the structure of the Zoraptera is probably somewhat more like that of the Corrodentia than of any other order. However, it appears that the group is about equally representative of the orthopteroid series. Tillyard (1926) thought that it formed a connecting link between the Isoptera and the Corrodentia. When the order was first described, only the apterous forms were known, and Silvestri (1913) assigned them to the Apterygota.

The shedding of the wings is an interesting phenomenon shared with the termites. Although there is not such a distinct "fracture suture" at the wing bases as in the termites, the wings are shed by being broken off along a definite zone of weakness. Dealated individuals retain the stumps of their wings as do dealated Isoptera. The wings are shed within a few days after maturity is reached, according to Gurney (1938).

A low type of caste system is suggested by the two forms of reproductives. One group attains sexual maturity without developing wings, whereas the other "caste" possesses wings at maturity. The winged forms are darkly pigmented, have the eyes and ocelli fully formed and develop from nymphs which usually have the compound eyes and ocelli present but feebly developed. The apterous forms are not pigmented, or at most are weakly pigmented, lack ocelli and have the compound eyes absent or at most feebly developed. The later stage nymphs of the winged forms have distinct wing pads which are never produced in the apterous forms. The number of instars has not been ascertained. The apterous forms are more numerous than the alates.

Zorapterans are usually found in colonies, and some writers have considered them subsocial. However, it is probable that they are only gregarious.

A specimen of *Zorotypus swezeyi* examined by me appeared to have the alimentary canal full of finely divided plant material (moldy wood?). No records of parasites of this order have come to my attention.

#### Family ZOROTYPIDAE Silvestri, 1913

#### Genus ZOROTYPUS Silvestri, 1913

#### *Zorotypus swezeyi* Caudell.

*Zorotypus swezeyi* Caudell, 1922:133. Gurney, 1938:72, pl. 3, figs. 42-43.

Kauai (type locality: Kokee), Oahu.

Immigrant(?). Caudell thought that this was a foreign species, perhaps "East Indian."

It appears to be a rare insect. A few specimens have been collected from rotten logs of *Acacia koa* on Kauai and Oahu, a rotten *Straussia* log on Oahu, and a rotten *Metrosideros* stump on Oahu. Only a single winged specimen has been found, and all the other examples collected have been apterous forms. All individuals taken have been collected exclusively in the damp mountains. The first specimens were found on Kauai in August, 1921, by Dr. Swezey.

Because the material now available is not adequate for illustration, I have reproduced Gurney's figures (1939) of the Fijian *Zorotypus zimmermani* Gurney, to illustrate the group. The female of this Fijian species is not greatly unlike that of the Hawaiian insect.

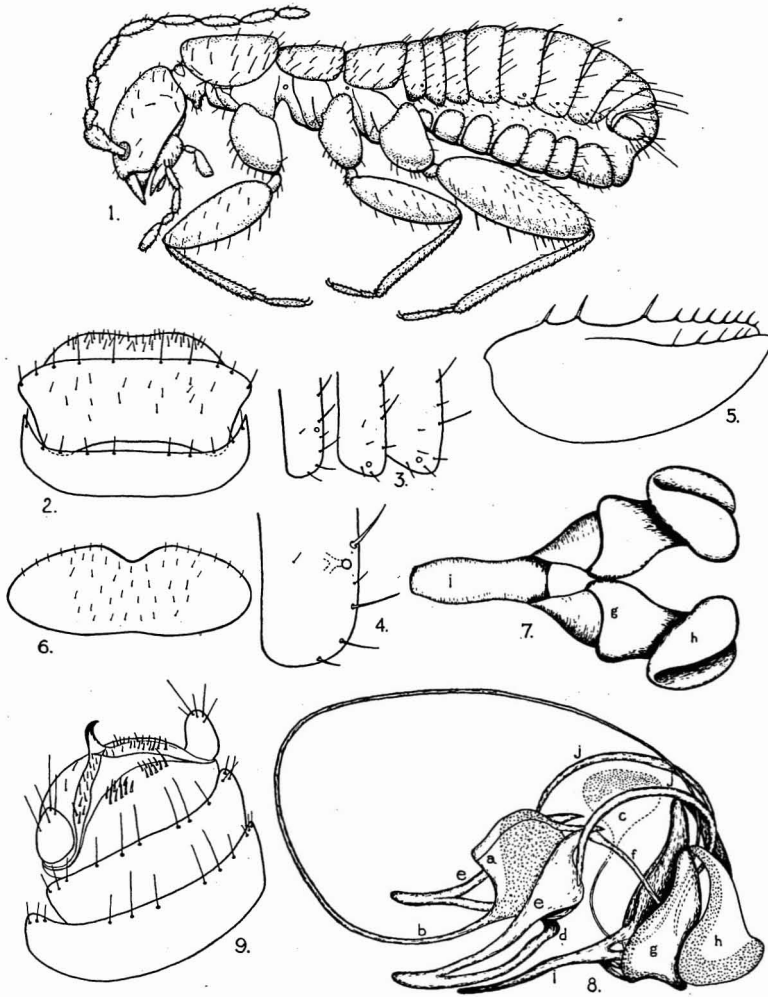


Figure 120—*Zorotypus zimmermani* Gurney. Although this Fijian species does not occur in Hawaii, this figure is reproduced here because adequate material of the Hawaiian form is not available. This species closely resembles the Hawaiian species, and the plate gives a good outline of the features of the order. 1, Apterous female; 2, subgenital and adjoining plates of apterous male; 3, left lateral part of tergites 1 to 3 of apterous female; 4, left lateral part of first tergite of apterous female; 5, outline of hind femur of apterous male, lateral view; 6, ventral view of subgenital plate of apterous female; 7, paired lobes and basal plate of genitalia of apterous male; 8, dorso-lateral view of genitalia of apterous male; 9, dorso-caudo-lateral view of apex of abdomen of apterous male. (After Gurney, 1939.)

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## Order **CORRODENTIA** (Burmeister, 1838)

(*corrodens*, gnawing)

*Copeognatha* Enderlein, 1903.

*Psocoptera* Shipley, 1904.

Psocids, Barklice, Booklice

Body comparatively soft, usually in part subject to shrivelling after death; head hypognathous or prognathous, large, exposed, free; labrum well developed; both anteclypeus (clypeolus) and postclypeus (clypeus; usually conspicuously inflated and bulbous) present; epicranium divided by a longitudinal median suture and joining a V-shaped suture separating the front and vertex; mandibles masticatory, asymmetrical, dentate, the teeth of one mandible fitting into grooves between the teeth of the other, molar area present; maxillary palpi four-segmented; labial palpi one- or two-segmented; maxillae bearing a pair of peculiar, long, retractile, chisel-like sclerotized rods (modified laciniae) ensheathed by the galea and capable of extrusion for a considerable distance from the "mouth" (rarely, these organs are absent); antennae elongate, filiform, 13- to about 50-segmented, longer than the body in most of our species; compound eyes (excepting in a few forms) large and in many species strongly protuberant, widely separated; ocelli present or absent (present in the majority of forms), three in number, the anterior one on the frons, the posterior pair lying one on either side of the median suture of the epicranium. Thorax with the prothorax large in some forms, but greatly reduced and largely concealed in most of the winged groups; mesothorax larger than metathorax. Legs usually cursorial, rarely saltatorial, tarsi two- or three-segmented, claws paired, empodium present. Wings variable, absent, partially or unequally developed or with four functional wings usually held roof-like over the body (but held flat over the body in some species when at rest), fore pair larger and with more complex venation than hind pair, true cross-veins absent or at most one or two present, a pterostigma present in fore wings of many forms, venation characteristic and comparatively simple, as in figure 121. Abdomen 10-segmented, the first sternite reduced or obsolete, the two terminal segments reduced; cerci absent; ovipositor present or absent; male genitalia symmetrical or asymmetrical, comparatively complicated in form and structure in many groups. Metamorphosis slight; eggs plain or sculptured, deposited singly or in groups on foliage, bark or other substratum in the vicinity of the food source, concealed by some forms beneath webs, enclosed in groups under a cement-like or dried frothy or crusty material (an anal secretion) in other forms, laid bare in others; some species viviparous, others parthenogenetic, but mostly normal in development; six instars, wing

buds present in second instar; mostly diurnal; mostly fungivorous, algivorous or lichenivorous, but with a varied assortment of habits within the order (some wingless forms have been recorded from living mammals), although the group is predominantly herbivorous (Pearman found that algae of the genus *Pleurococcus* formed the principal food of some psocids, and that certain psocid species ate only particular species of *Pleurococcus*); some species live in small colonies beneath delicate webbings and most are rapid in their movements. Pearman (1932: 90-96, figs. 1-8), gives notes and descriptions of coccophagous species which were said to feed upon *Pseudococcus citri* in East Africa.

Fossil psocids have been described from the Miocene, Oligocene and Upper and Lower Permian. The Permian species had five-segmented tarsi—the primitive hexapod tarsal number. There are evidently about 1,000 living species known today, but further study will greatly expand this number.

There are 40 species listed here as occurring in Hawaii, but I have seen several additional unrecorded species. Of the total number of recorded species, 24 are endemic, whereas the other 16 are all considered immigrants. The native forms belong to the genera *Psocus*, *Kilaueella* and its offshoot *Palistreptus*. They are Polynesian derivatives.

Many psocids spin silk from the openings of their silk glands in their oral cavities to use in covering their eggs or to produce a webbing beneath which they live in small colonies. Some extra-Hawaiian species spin large amounts of webbing on trees and thus produce an unsightly appearance. It is thought that the webbing serves as an efficient protection from enemies—especially ants.

Psocids have many enemies. The minute mymarid wasp *Alaptus* parasitizes the eggs of some species. Ants, green and brown lacewings, dolichopodid flies, emesid and reduviid bugs are known to prey upon them. They probably constituted the principal food for such predators as the lacewings in these originally aphid-free islands.

Many species are rapid in movement, and many, although fully capable of active flight, will show great reluctance to take wing and will dodge about on their host-plants even if persistently annoyed and pursued.

The Corrodentia are evidently most closely allied to the Zoraptera which connect them with the orthopteroid stocks on the one hand, and to the lice—the Mallophaga and Anoplura—on the other hand. Tillyard (1923:173) believed that the lice were derived from an ancient wingless psocid stock, and he points out that "...it is worthy of note that wingless Psocoptera are even known at the present day to live upon mammals." Weber (1939, reference not seen) placed the Mallophaga, Anoplura and psocids all in one group, the Psocoidea.

The usual wing venation in the Corrodentia is quite distinct from that found in any other order of insects. Figure 121 and others adequately illustrate the usual types of venation. The absence of true cross-veins is striking. The irregular courses of sections of the main veins replace cross-veins. The only insects which have wing venation which superficially resembles that of the Corrodentia are the Psyllidae and Coniopterygidae—unrelated groups—and the allied Zoraptera.

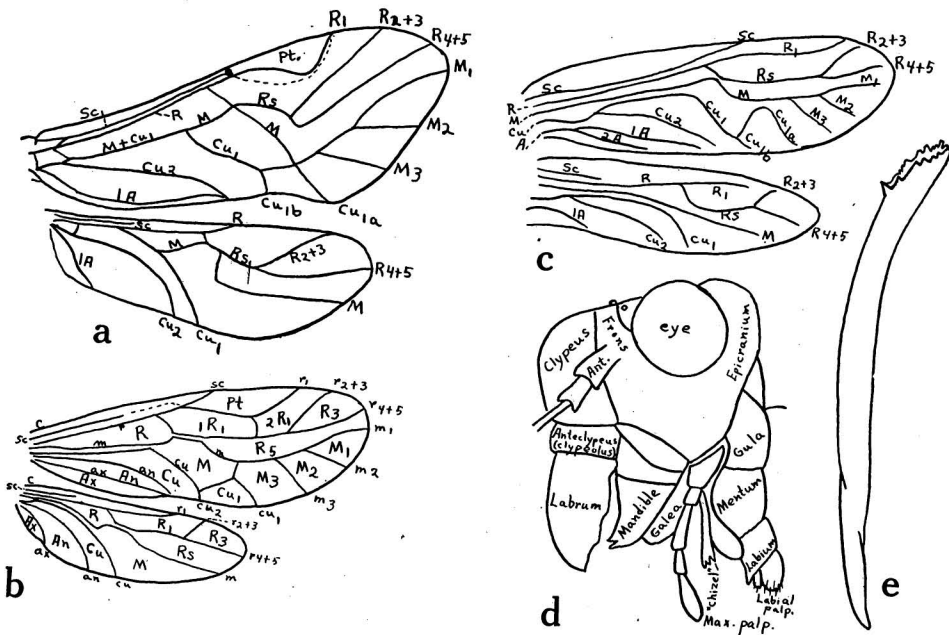


Figure 121—Details of psocids: a, wings of *Myopsocus* (redrawn from Tillyard, 1923); b, wings of *Caecilius* (veins drawn separated to show courses), veins labeled in lower case letters, cells in capital letters (redrawn from Enderlein, 1903). (Note the difference in nomenclature used by Tillyard and Enderlein.) c, Tracheation of wings of last nymphal instar of a *Psocus* (redrawn from Tillyard, 1923); d, head of a *Psocus* (redrawn from Enderlein, 1903); e, maxillary "chisel" (redrawn from Enderlein, 1903).

The peculiar maxillary chisels ("maxillary forks," "picks," "styliform appendages," "laciniae," "rods," "paragnatha," "furcae maxillares") are unique among insects. However, a rather similar structure is said to be found in certain Mallophaga. It is thought by some workers that these structures are used to cut fungal mycelia and other food and for bursting fungal spore cases; but Pearman (1928: 268) does not agree that they are used for such purposes. These organs are usually complexly dentate or incised at the apex and afford good characters of identification.

The psocids found in Hawaii range in size from about 1 mm. in length in the wingless immigrant *Liposcelis* to slightly more than 1 cm. in wing expanse in certain endemic *Psocus*.

The Corrodentia are a taxonomically difficult assemblage, and great differences of opinion as to their classification exist among various authors who have studied them. Comstock, in his *An Introduction to Entomology* (1933), recognized only two families in the order, but Pearman's classification of 1936 lists 26 families in eight supra family categories. In 1909, Enderlein divided the order into two suborders principally on the basis of the number of segments in the tarsi. According to this view, the suborder Isotecnomena contains those psocids whose immature and mature stages have two-segmented tarsi, and the single-segmented labial palpi.

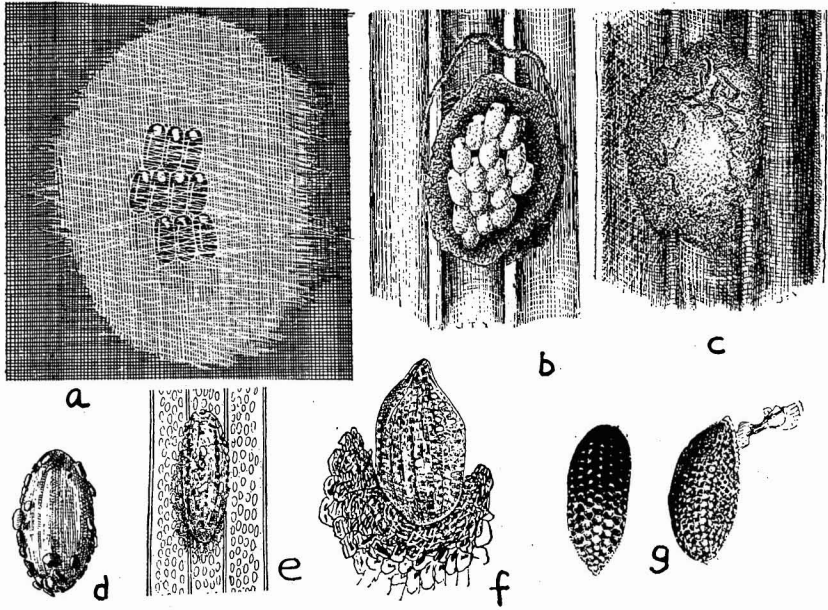


Figure 122—Eggs of some psocids: a, *Caecilius analis* Banks, webbed-over cluster of eggs on leaf of sugarcane, eggs 0.5 mm. long; b-c, uncovered and covered cluster of eggs of *Hemipsocus roseus* (Hagen) on a sugarcane leaf, cover about 3 mm. long; d, egg of *Ectopsocus fullawayi* Enderlein, length about 0.35 mm.; e, egg of *Psylloneura williamsi* Banks, on leaf of sugarcane, length about 0.45 mm.; f, egg of *Cyptophania hirsuta* Banks, length about 0.45 mm.; g, eggs of *Lepidopsocus costalis* (Banks), right egg hatched and showing cast amniotic membrane, egg length 0.4-0.5 mm. (Rearranged from Banks, 1931.)

The suborder Heterotecnomera contains psocids whose immature stages have two-segmented tarsi, but the adults have three-segmented tarsi and most of them have two-segmented labial palpi. Tillyard (1923:173), commenting upon this classification, said, "... it seems quite clear that this subdivision does not represent the original dichotomy of the order, but merely separates the three most highly specialized families from all the rest. The more archaic representatives of the order are so rare, and so little is known about them that much more work remains to be done before we shall be in a position to offer a classification of the order which truly represents its main lines of evolution." In 1926, Tillyard, after studying fossil psocids, proposed a new division of the order based upon wing venation, antennal and prothoracic characters and used the subordinal names Parapsocida and Euopsocida. It seems to me that Tillyard's work warrants more credit and consideration than it appears to have received. Banks, in 1929, proposed a different and much simplified classification of the order based principally on wing venation. Karny (1930) published a detailed revised classification with keys to families, subfamilies and tribes and a complete list of the genera. Karny's system is quite different from any of the others. Pearman (1936) has proposed a radically revised classification, but, unfortunately, his published work includes only an outline unsupported by descriptive details. He is, however, preparing a detailed and com-



prehensive revision of the order, but owing to the difficulty of the task, it will be a long time before his results will be available in published form. Each of the above-mentioned systems differs greatly from the others, and to one unfamiliar with the group it appears that psocid taxonomy is in chaos.

For these and other reasons, it is felt that this work would better serve the Hawaiian students if a simpler and more or less arbitrary and tentative classification were used. Thus, the conclusion has been reached that a compromise arrangement is the more feasible course to follow for the Hawaiian species at the present time. It is one of the principal aims of this volume to aid students in determining their material, and an arrangement of the psocids is presented here which, it is hoped, will aid the worker more than if an attempt were made to follow entirely any one authority. However, the original manuscript has been revised to make it fall more in line with Pearman's work. The keys and general classification used here are not intended to be natural arrangements—the text is written principally to facilitate identification. In all the keys in this chapter, the characters used are based principally upon Hawaiian psocids, and it is not intended that they will hold good for other faunas. It must remain for some future worker to place the Hawaiian Corrodentia upon a sound and proper foundation.

[*Note.* After this manuscript was completed, Mr. Pearman sent me a carefully and laboriously prepared outline of his revised classification, complete with meticulously drafted illustrations. With utmost generosity he suggested that I incorporate his entire work in this manual. I appreciate greatly his unfettered spirit of scientific cooperation, but I feel that the revolutionary results of his long labors should await the time when they can be published entirely under his own name with the full and just credit falling where it should. If it had not been for the war and the consequent delays of communication and other resultant impediments, we might have worked out the Hawaiian psocids in closer cooperation. I owe Mr. Pearman many thanks for answers to numerous questions and other aid given in spite of the handicaps of wartime conditions in war-torn England. It is to be hoped that he may complete without further delay his revised classification with ample keys, descriptions and illustrations and have them published so that they may be available to all workers.]

The Corrodentia of Oceania are poorly and inadequately known. Future studies of collections assembled at the Bishop Museum and elsewhere will probably reveal that a number of the immigrant species which are now known only from the Hawaiian Islands are widespread on other Pacific islands. A cursory examination of some of our collections has already revealed extra-Hawaiian distribution for some species (for example, see *Ectopsocus*). The Hawaiian psocids have received more attention than those of any other Polynesian archipelago, but only three men—Perkins, Enderlein and Banks—have studied our species systematically, and much remains to be done. Perhaps not one-half of our local psocid fauna is known.

This group offers a fertile field of endeavor for a careful, ambitious worker. Most species shrivel considerably upon drying, and, without considerable care,

many psocids mounted dry are difficult to work with. For this reason, perhaps, few workers are encouraged to specialize in these interesting animals. Some workers prefer material collected and preserved in alcohol. However, the hairy and squamose species lose their wing scales and hairs and their colors are hard to distinguish in alcohol-preserved material. Excellently prepared specimens of at least the larger forms can be had if the individuals are carefully collected in dry vials and mounted with great care promptly after death. Dry material supplemented by duplicates preserved in alcohol or mounted on slides will greatly aid in the study.

TABULAR ANALYSIS OF THE HAWAIIAN CORRODENTIA

FAMILY	GENERA	ENDEMIC GENERA	NON- ENDEMIC GENERA	SPECIES	ENDEMIC SPECIES	ADVENTIVE SPECIES
Perientomidae	2	0	2	4	0	4
Psoquillidae	1	0	1	1	0	1
Liposcelidae	1	0	1	1	0	1
Pachytroctidae	1	0	1	1	0	1
Psocathropidae	2	0	2	2	0	2
Caeciliidae	2	0	2	2	0	2
Peripsocidae	2	0	2	4	0	4
Hemipsocidae	1	0	1	1	0	1
Elipsocidae	2	2	0	10	10	0
Psocidae	1	0	1	14	14	0
Totals	15	2	13	40	24	16

Percentage of endemism in native group: genera 66½ percent; species 100 percent.

Percentage of present-day fauna native: 60 percent.

Percentage of present-day fauna adventive: 40 percent.

Average number of species per genus in native group: 8.

Average number of species per genus in adventive group: 1.3.

## KEY TO THE FAMILIES OF CORRODENTIA FOUND IN HAWAII

1. Wings absent; meso- and metathorax fused so that thorax appears to be only two-segmented; hind femora broadly expanded ..... **Liposcelidae.**  
At least fore wings present, although all wings may be reduced in size; thorax normal, three-segmented; hind femora not so expanded..... 2
- 2(1). Fore wing membrane densely hirsute or squamose..... **Perientomidae.**  
Fore wing membrane not hirsute or squamose..... 3
- 3(2). Hind wings greatly reduced in size or absent..... 4  
Hind wings present and at least moderately large..... 6
- 4(3). Tarsi two-segmented; ocelli present; wings as illustrated (fig. 127, e)..... *Chaetopsocus* of **Peripsocidae.**  
Tarsi three-segmented; ocelli absent; wings obviously different ..... 5
- 5(4). Fore wing with a cross-vein between  $R_1$  and  $R_s$ , thus making a closed cell at about middle of wing, as illustrated (wings clear in our species) (fig. 127, c).....  
..... *Psocathropus* of **Psocathropidae.**

- Fore wing without such a cross-vein and closed cell, as illustrated (wings opaque brown in our species) (fig. 126, c-d) ..... **Psoquillidae.**
- 6(3). Fore wings without a distinct pterostigma (fig. 127, a-b) ... 7  
 Fore wings with radius subsinuate distad and forming a distinct pterostigma (fig. 130) ..... 8
- 7(6). Fore wing with a cross-vein between  $R_1$  and  $R_s$ , thus making a distinct, closed cell at about middle of wing, as in figure 127, b. .... *Psyllipsocus* of **Psocathropidae.**  
 Fore wing without such a cross-vein and closed cell. ....  
 .... *Psylloneura* of **Pachytroctidae.**
- 8(6). Fore wing with areola postica (cubital cell) absent (figs. 127, e; 129) ..... **Peripsocidae.**  
 Fore wing with areola postica present (fig. 130) ..... 9
- 9(8). Fore wing vein  $Cu_1$  either touching or joined to vein M by a cross-vein so that enclosed cells M and  $M_3$  are formed (figs. 130, a; 135) ..... 10  
 Fore wing with vein  $Cu_1$  distant from M and not forming cells M and  $M_3$  (fig. 130, b) ..... 11
- 10(9). Fore wing veins without setae ..... **Psocidae.**  
 Fore wing veins with setae ..... 12
- 11(9). Tarsi two-segmented ..... **Caeciliidae.**  
 Tarsi three-segmented (check carefully; the second segment is difficult to see on some dried specimens; it may be necessary to put a tarsus in alcohol or other fluid to see the segments distinctly) ..... **Elipsocidae.**
- 12(10). Tarsi two-segmented ..... **Hemipsocidae.**  
 Tarsi three-segmented ..... part of **Elipsocidae.**

#### Family PERIENTOMIDAE Enderlein, 1927

The Hawaiian members of this family can be distinguished from all our other psocids because the fore wings are densely clothed with hairs and scale-like hairs. The tarsi are three-segmented. Pearman (1936) uses *Lepidopsocidae* for this group, but *Perientomus* is the older name.

#### KEY TO THE GENERA OF PERIENTOMIDAE FOUND IN HAWAII

1. Hind wings developed ..... **Lepidopsocus** Enderlein.
2. Hind wings aborted ..... **Cyptophania** Banks.

After examining drawings prepared by me, Mr. J. V. Pearman, in a letter dated February 14, 1940, states that *Echmepteryx marmorata* Banks really belongs to *Lepidopsocus*. The other local *Echmepteryx* follow this species into *Lepidopsocus*. The new combinations appear below.

Karny (1930) assigns both *Lepidopsocus* and *Echmepteryx* to the Echmepterygini of the Perientominae, which he includes with the Amphientomidae.

Genus **LEPIDOPSOCUS** Enderlein, 1903

This is an Indo-Pacific genus with representatives also on certain islands of the Indian Ocean. The wings are narrow and characteristically pointed at their apices.

## KEY TO THE SPECIES FOUND IN HAWAII

1. Hind wings with vein  $R_{2+3}$  distinctly more than one-half as long as  $R_{4+5}$ , arising from  $R_2$  at a point only about one-fourth of its length from origin of  $M_{1+2}$  (see fig. 124, c) ..... **marmoratus** (Banks).  
Hind wing with vein  $R_{2+3}$  distinctly less than one-half as long as  $R_{4+5}$  and arising from  $R_2$  at a point distinctly more remote from origin of  $M_{1+2}$  than its length (see fig. 124, a-b) ..... 2
2. Vestiture of fore wings dark brown from base to apex down median part of the wing, and with a band of white along both fore and hind margins; venation of hind wing as in figure 124, b; hair on head not very dense and shaggy ..... **costalis** (Banks).  
Vestiture of fore wings almost concolorous, golden or yellowish brown, without a distinct dark and pale pattern; venation of hind wing as in figure 124, a; head bristling with very dense, shaggy hair ..... **unicolor** (Banks).

**Lepidopsocus costalis** (Banks), new combination (figs. 122, g; 123; 124, b).

*Echmepteryx costalis* Banks, 1931 :439, pl. 7, fig. 3; pl. 8, fig. 3; pl. 9, fig. 4 (eggs).

Oahu (type locality: Ewa).

Immigrant, but source unknown.

This species has been found on sugarcane, coconut, papaya and other plants.

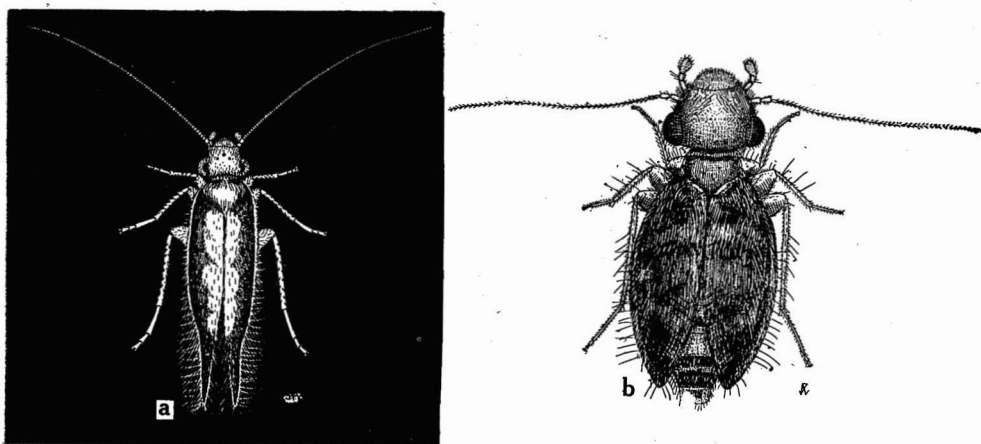


Figure 123—*Lepidopsocus costalis* (Banks), left; *Cyptophania hirsuta* Banks, right. (From original drawings by Yamamoto and Williams for Banks, 1931.)

The color pattern on fresh, unrubbed specimens is striking and diagnostic. The dark scales, some of which are iridescent, make a broad vitta down the entire length of the wing, and the fore and hind margins are white and contrast sharply.

**Lepidopsocus marmoratus** (Banks), new combination (fig. 124, c).

*Echmepteryx marmorata* Banks, 1931:439.

Oahu (type series from Kualoa and Honolulu), Maui.

Immigrant, but source unknown.

Hostplants: tomato, *Acacia koa*, *Albizia*, *Coprosma*, *Erythrina*, *Euphorbia*, *Plumeria*.

The fore wings are conspicuously spotted with white and brown.

**Lepidopsocus unicolor** (Banks), new combination (fig. 124, a).

*Echmepteryx unicolor* Banks, 1931:439.

Immigrant, but source unknown.

The golden or yellowish fore wings are distinctive.

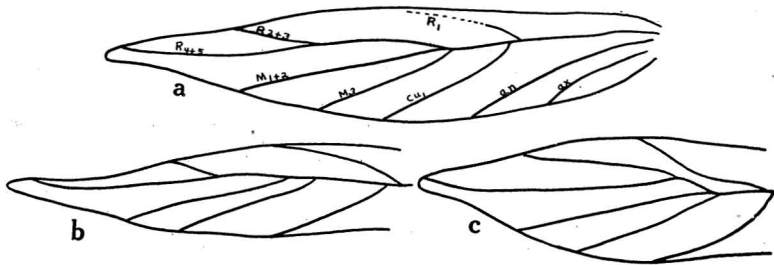


Figure 124—Sketches of hind wing venation of *Lepidopsocus* species: a, *L. unicolor* (Banks); b, *L. costalis* (Banks); c, *L. marmoratus* (Banks).

In addition to these three species, Swezey and I have each collected a specimen of a beautiful yellow-gold species which has as yet not been identified. It will run to *unicolor* in the key, but its color, wing venation and less densely hairy head will serve to distinguish it.

### Genus **CYPTOPHANIA** Banks, 1931:440

*Cryptophania* (Banks), error in Neave, Nomenclator Zoologicus, 1939.

This genus is monotypic. The hind wings are wanting. Banks originally placed it as a relative of *Psocinella*.

**Cyptophania hirsuta** Banks (figs. 122, f; 123).

*Cyptophania hirsuta* Banks, 1931:440, pl. 7, fig. 1; pl. 8, fig. 7; pl. 8, fig. 5 (eggs).

Oahu (type locality: Honolulu), Hawaii.

Immigrant. Source unknown.

The type series was taken on sugarcane, and others have been taken on *Urera*, *Acacia koa*, *Sideroxylon* and on ferns, including *Cibotium*, in the mountains.

This peculiar, running and jumping species is easily recognized because of its densely hairy brown fore wings which are more or less elytra-like and fit together in a straight line for more than one-half of their lengths down the back and do not overlap. There are two types of hair on the wings: one is prostrate, whereas the other is long and bristling erect.

Williams (1931:88) says, "The eggs are somewhat like those of *Echmepteryx [costalis]*, but stouter and of a sort of salmon color. It occurs in the mountains, and in the cane fields is more or less terrestrial."

#### Family PSOQUILLIDAE Kolbe, 1884

#### Genus **PSOQUILLA** Hagen, 1865:123

***Psoquilla margine-punctata*** Hagen (fig. 126, c-d).

*Psoquilla margine-punctata* Hagen, 1865:123. McLachlan, 1867:7, pl. 2, fig. 4.

Enderlein, 1925:107, fig.

*Heteropsocus dispar* Verrill, 1902:817, figs. 192, 192a-b (described from Bermuda).

Kauai, Oahu.

Immigrant. Widespread in the tropics; described from a specimen taken in a German hothouse. First found in Hawaii at Honolulu by Swezey in 1918.

This species is easily recognized among our psocids because of its distinctly spotted fore wings. The wing membrane is brown with conspicuous white spots arranged as in figure 126. Roesler (1940:225, fig. 1) discusses and figures the macropterous female; I have not seen the macropterous form in Hawaii. (See also Pearman, 1935:83-84.)

Dr. Swezey found this species in bran in Honolulu and on the bark of "kauwila" (*Alphitonia*?) on Kauai. Takahashi (1938:11) said that this species has been found abundant in stored grain in Formosa. I found it common on moldy boards on the sides of boxes containing rotten fruits from which melon flies were being bred in June, 1943. It runs very rapidly and is difficult to capture.

#### Family LIPOSCELIDAE Pearman, 1936:59

*Trogiidae* Enderlein, 1911.

*Atropidae* Kolbe, 1884 (*Atropos* is invalid; it is a synonym of *Trogium*. See Gurney, 1939:510).

*Troctidae*, of authors.

The fused meso- and metathorax together with the absence of even vestiges of wings will readily distinguish this family from the others found in Hawaii. The tarsi are three-segmented.

Genus **LIPOSCELIS** Motschulsky, 1853

There is more than one species in this genus established in Hawaii, but I have been unable to identify them.

**Liposcelis divinatorius** (Müller) (fig. 125).

*Termes divinatorium* Müller, 1776:184.

See Gurney (1939:513) for synonymy and discussion.

The booklouse (also called the death watch, cereal psocid, book-tick and cabinet mite).

Widespread in Hawaii and probably present on at least all the main islands, but no detailed locality records have been assembled.

Immigrant. Cosmopolitan. It has been in the islands for many years.

Parasite: *Alaptus globosicornis* Girault (Hymenoptera: Mymaridae, a minute insect, and one of the smallest of all insects in Hawaii, if not the smallest), in the eggs.

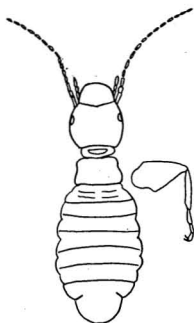


Figure 125—*Liposcelis divinatorius* (Müller) ?; the hind leg is separately outlined.

A widespread insect long associated with man. It is a common pest in warehouses, stores, kitchens, museums and other places where it attacks, especially, cereals and cereal products; it also damages insect, plant and other museum collections, and it has been accused of feeding upon various plant and animal materials as well as the pastes in book bindings. Large colonies are likely to develop on moldy articles, because certain fungi are eagerly consumed. In fact, it is probable that fungi usually constitute the principle diet of this psocid, but colonies will sustain themselves for years on dry cereals where no mold is present. In spite of its omnivorous habits, however, this pest is most important economically because of

its infesting foodstuffs—especially cereals. It is not so much the consumption of food materials that makes the insect a pest as its mere presence which causes much infested food to be thrown away. I have had many infestations in flour, yellow corn meal and ground breakfast cereals in my own kitchen and have seen examples taken from prepared fish food and almonds, and Mr. Pemberton has shown me polished rice and dried yeast which were considerably damaged by this insect. In spite of these and other similar observations, Back (1939:3) refers to them as "harmless creatures." The minute size of the insect gives it access to packaged articles which may appear to be insect-proof.

This insect has long been accused of damaging book bindings, paper and other materials, but the latest information available leads to a contrary conclusion. Back (1939) suggests that damage caused by cockroaches and silverfish has been erroneously assigned to psocids.

This species is only a millimeter or somewhat more in length, completely apterous, grayish white or pale yellowish with black eyes; the meso- and metathorax are so fused that the thorax appears to consist of only two segments; the eyes are unusually small; the hind femora are enlarged, as illustrated in figure 125. It is considered the smallest known psocid.

Back (1939:3) notes that in the southern United States in summer the "... eggs hatch in 4 to 11 days, and each female lays on an average of about 60 eggs ..." and that "Development from egg to adult may be completed in from 3 to 4 weeks during the warmer months." No life history studies have been made in Hawaii to my knowledge. This species develops parthenogenetically. Rosewall (1930) found no males after several years' study of laboratory cultures.

Pearman (1928:216) says, "Eggs scattered, ovoid, translucent greyish with purplish iridescence, more or less thickly sprinkled with granular particles derived from surrounding objects; no enveloping pellicle observable."

These psocids are reported to require warmth and high humidity for optimum development and are especially apt to build up large populations during warm, damp weather. Evidently the conditions that favor the development of minute molds are largely responsible for the fluctuations of populations in Hawaii. Damp places such as basements usually support thriving colonies and damp wood and other damp articles are likely to be infested. On the other hand, I have kept a colony thriving for several years in a tightly closed jar of dry corn meal.

The term "death watch" comes from the alleged habit of these insects making a ticking sound by striking their venters against whatever they happen to be on, thus occasionally making a faint but audible sound. Imms (1934), following Pearman, says that sound production has not been proved for this species, but it has for "*Clothilla pulsatoria* and *Lepinotus inquilinus*," and that the ticking is considered a mating call employed by the female.

Control: The best control is fumigation with a fumigant such as hydrocyanic gas or methyl bromide. Carbon tetrachloride is good for eliminating infestations in insect boxes, cabinets and similar small enclosed articles and is safe to use in the



home. Naphthalene and paradichlorobenzene will prevent infestations and will kill out the pests if confined. A 5 percent solution of DDT sprayed over areas infested with psocids will give good control for a long time. Rooms and similar places can be cleared by heating to 125° F. for several hours. Infested foodstuffs may be carefully heated in an oven at 125° to 130° F. to destroy all stages. Infested moldy articles such as shoes and boots should be wiped clean, dusted and placed in direct sunlight for several hours to kill all stages. Pyrethrum, derris and sodium fluoride dusts and oil-pyrethrum sprays are effective in control. Although control methods may rid a place of these psocids, it is likely that reinfestation will occur in a short time because of the abundance and widespread distribution of the animals and the ease with which they gain access to new quarters. Also, the adults may be killed off, but viable eggs may remain after fumigation.

A species which has similar habits to this species and is frequently found in the same places in other areas is *Trogium pulsatorium* (Linnaeus). It has become widespread and it is expected that it will become established in Hawaii. It has not yet been found here to my knowledge, however. It has minute fore wings and the body is marked with dark dots and patches.

#### Family PACHYTROCTIDAE Pearman, 1936:60

##### Genus PSYLLONEURA Enderlein, 1903

Karny assigns the genus to the Rhypsocini of the Empheriini, which he places in the "Trogidae."

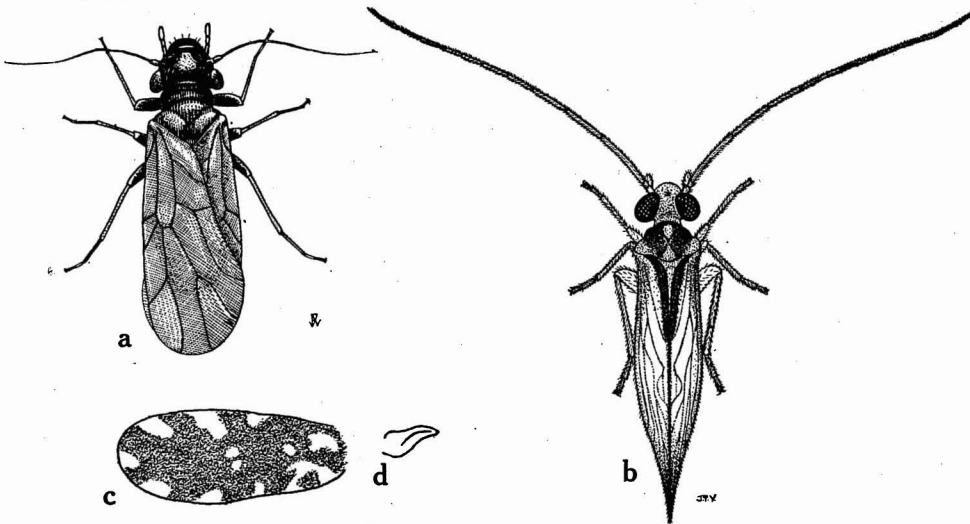


Figure 126—*a*, *Psylloneura williamsi* Banks; *b*, *Caecilus analis* Banks; *c-d*, fore and hind wings of *Psoquilla margine-punctata* Hagen. (*a* and *b* from original drawings by Williams and Yamamoto for Banks, 1931.)

**Psylloneura williamsi** Banks (figs. 122, e; 126; 127, a).

*Psylloneura williamsi* Banks, 1931:439, pl. 7, figs. 8, 9; pl. 8, fig. 6; pl. 9, fig. 7 (eggs).

Oahu (type series from Ewa and Waialua).

Immigrant, but source unknown.

The type series was collected from sugarcane.

Banks' figure of the venation of the hind wing is erroneous and misleading. Vein  $R_{2+3}$  is not vertical, but it is oblique; the anal vein is not as dark and heavily developed as the others; the axillary vein is present. These omissions as well as others including the proper shapes of the wings are herein corrected by new figures which were made from specimens from the type series.

This species folds its wings flat over its body when at rest. Williams (1931:88) says, "It lays its eggs singly; these are about 0.45 mm. long and rather slender oval and more or less covered with tiny bits of excrement. It has been found tolerably common on sugarcane trash...."

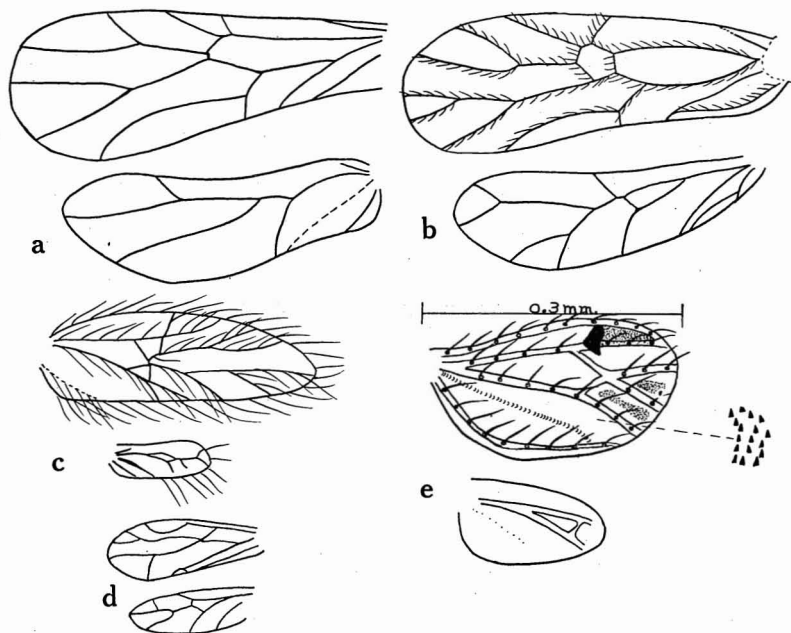


Figure 127—Sketches of some psocid wings: a, *Psylloneura williamsi* Banks; b, *Psyllipsocus minutissimus* (Enderlein); c, *Psocathropos lachlani* Ribaga; d, *Hageniola solitaria* Banks (copied from Banks, 1931, and not checked with specimens); e, *Chaetopsocus richardsi* Pearman.

#### Family PSOCATHROPIDAE Pearman, 1936:60

##### KEY TO THE GENERA FOUND IN HAWAII

1. Hind wings nearly as long as fore wings, without marginal setae; fore wings as illustrated, setae on veins moderate in length, but without marginal setae.....**Psyllipsocus** Selys.

2. Hind wings much reduced, with some long marginal setae; fore wings as illustrated, bristling with very long setae, and margins with very long bristles.....**Psocathropos** Ribaga.

Genus **PSYLLIPSOCUS** Selys, 1872

**Psyllipsocus minutissimus** (Enderlein) (fig. 127, b).

*Paremptheria minutissima* Enderlein, 1920:458. Takahashi, 1938:11, redescription. Gurney, 1943:203-205, nomenclature.

Oahu (type locality: Koolau Mountains).

Immigrant. Takahashi (1938:12) recorded this species as rather common in dwellings in Formosa.

To my knowledge, this species has not been recorded in Hawaii since it was described from a unique female. I found it among molds growing on a bottle of rum in a cupboard at Punaluu, Oahu, in 1943. It is a distinct, delicate little species which should not be confused with any of our other psocids.

Genus **PSOCATHROPOS** Ribaga, 1899

**Psocathropos lachlani** Ribaga (fig. 127, c).

*Psocathropos lachlani* Ribaga, 1899:158, pl. 7.

Oahu.

Immigrant. Described from an Italian hothouse and now also known from Africa. First found by Swezey in Honolulu in 1927.

This peculiar little species is an active and agile jumper and can leap several inches—a prodigious distance for such a minute creature. When jumping on paper, it can be heard more easily than seen. It is recognized easily by its clear wings, which have unusually long bristle-like hairs on the veins and wing margins, and by its pale body. It has at times been abundant about books in my laboratory and home and appears to reproduce rapidly in damp weather. I believe that this is the species I once found in numbers on a pair of moldy boots in Honolulu. Excellent control has been obtained by cyanide fumigation, and naphthalene is a good repellent and will kill the psocids in closed compartments.

Family **CAECILIIDAE** Kolbe, 1884

Two genera are included here. Each of these has two-segmented tarsi, fore wings with setose veins and margins and the areola postica present. I have not seen *Hageniola*, and I am not sure that it should be included here, although it was assigned to the Caeciliinae by Banks when it was described. Karny (1930) places *Caecilius* in the Lachesillini of the Lachesillidae.

## KEY TO THE GENERA OF CAECILIIDAE FOUND IN HAWAII

1. Media of fore wings with two branches (fig. 130, b)..... **Caecilius** Curtis.
2. Media of fore wings with only one branch (fig. 127, d)..... **Hageniola** Banks.

Genus **CAECILIUS** Curtis, 1837

This genus is almost cosmopolitan in distribution. In addition to the species recorded below, I have seen specimens of another as yet unidentified species.

**Caecilius analis** Banks (figs. 122, a; 126, b; 130, b, c).

*Caecilius analis* Banks, 1931:437, pl. 7, fig. 2; pl. 8, fig. 2; pl. 9, fig. 3 (eggs).

Oahu (type locality). (It is probably present on other islands, but it has been neglected by collectors.)

Immigrant. This species is also known from the Marquesas, and it will probably be found to be widespread.

It has been found on sugarcane, *Cheirodendron* and other trees and shrubs; I found it abundant on various shrubs on the summit of Mount Konahuanui in May, 1943 (altitude over 3,000 feet). In life it is mostly pale lemon-yellowish with black eyes, with the antennae pale at the base but becoming fuscous distad, the area between the axillary vein and hind margin of the fore wings fuscous, and some variable fuscous marks on the thoracic nota, the latter markings rather extensive on some examples.

Genus **HAGENIOLA** Banks, 1931:438

This genus is known thus far only from the Hawaiian Islands, but its discovery elsewhere depends only upon further collecting or the study of undetermined collections. I have seen no representatives of the genotype, and from the figures given by Banks, it appears very different from any other genus known from our fauna. It may not be correctly placed here.

**Hageniola solitaria** Banks (fig. 127, d):

*Hageniola solitaria* Banks, 1931:438, pl. 7, fig. 5. Genotype.

Oahu (type locality: Honolulu).

Immigrant. Source unknown.

The type was collected on sugarcane.

## Family PERIPSOCIDAE Karny, 1930

## KEY TO THE GENERA FOUND IN HAWAII

1. Wings reduced as in figure 127, e. . . . . **Chaetopsocus** Pearman.
2. Wings fully developed for flight. . . . . **Ectopsocus** McLachlan.

Genus **CHAETOPSOCUS** Pearman, 1929:105

When Pearman described this genus he considered it allied to *Trichopsocus* Kolbe, 1882. However, later he obtained additional material, found that he had mistaken its characters and relationships and submerged it with *Ectopsocus*. He said (1942:291) that it was allied to "*Ectopsocus*, from the genotype of which, however, it differs in some significant respects." In spite of its different characters and appearance, Pearman thought that it would be best to sink *Chaetopsocus* until more comparative morphological studies could be completed and "until it is known whether it will typify a particular segregate . . ." Pearman's *richardsi* differs so greatly in structure, facies and habit from our species of *Ectopsocus* that I believe that it would be misleading and illogical to place the two groups together in this manual, although it may be a flightless *Ectopsocus* derivative.

**Chaetopsocus richardsi** Pearman (fig. 127, e).

*Chaetopsocus richardsi* Pearman, 1929:105, figs. 1, a-d.

*Ectopsocus richardsi* (Pearman) Pearman, 1942:290 (corrected redescription).

Oahu.

Immigrant. Not reported from Hawaii before, but first found in Hawaii in 1943 by J. S. Rosa at Honolulu in large numbers in a package of beans imported from North America. It was originally described from one adult female and one nymph taken from West African cacao on a London wharf, and later (Pearman, 1942:290) it was found in cacao at Winnebah, Gold Coast.

This is a minute and peculiar psocid about 1.5 mm. long. There is no other psocid in Hawaii which might be confused with this strange species. It has a dark brown head, the fore wings are only 0.3 to 0.4 mm. long, the venation is difficult to trace, and there is a tendency toward variation in both pairs of wings. All the specimens I have seen are micropterous, but Pearman found that "some females have wings of greater length, in a few cases of nearly full development with complete Ectopsocid venation." The type has short wings, the fore pair of which does not reach the posterior margin of the third abdominal segment. Some males and females examined by Pearman had longer wings that extend farther caudad, but not beyond the middle of the abdomen, and 10 percent of the females had the wings "Extending beyond middle of abdomen but not, or barely, beyond its apex."

Genus **ECTOPSOCUS** McLachlan, 1899

Some workers place this genus in the Caeciliidae. The fore wings lack the areola postica and have at most minute and inconspicuous hairs on the veins and the marginal setae are microscopic or apparently absent. The tarsi are two-segmented.

In addition to the three following species, I have seen and collected other apparently undescribed species of this genus in the Hawaiian Islands. Two of the three species recorded from Hawaii heretofore have not been reported elsewhere, but I have collected all three of them outside the Hawaiian Islands. They have evidently been spread widely over the Pacific through the aid of commerce. The genus is almost cosmopolitan.

KEY TO THE SPECIES OF **ECTOPSOCUS** FOUND IN HAWAII

1. Fore wing clear or slightly embrowned, without any color pattern (fig. 129, b).....**hawaiiensis** Enderlein.  
Fore wing dark, with conspicuous pale markings..... 2
2. Fore wing with a transverse pale band near base entirely across the wing as in figure 129, c-d.....**fullawayi** Enderlein.  
Fore wing without such a pale subbasal band, with at most a pale basal patch in the anal and axillary cells as in figure 129, a.....**perkinsi** Banks.

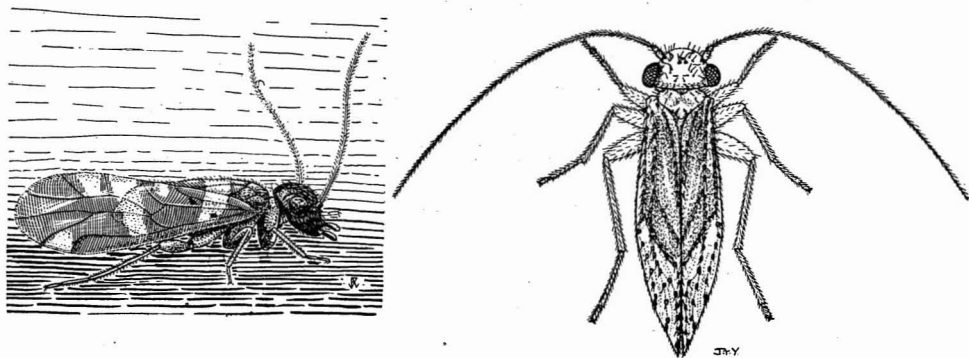


Figure 128—*Ectopsocus fullawayi* Enderlein, left; *Hemipsocus roseus* (Hagen), right. (From original drawings by Williams and Yamamoto for Banks, 1931.)

***Ectopsocus fullawayi*** Enderlein (figs. 122, d; 128; 129, c-d).

*Ectopsocus fullawayi* Enderlein, 1913:356.

Oahu (type locality: Honolulu), Laysan.

Immigrant. I collected this species at light at the Naval Station at Tutuila, Samoa, in 1940, and in 1934 at Tubuai, Austral Islands, at Pitcairn Island, Oeno Island, Henderson Island and Mangareva Island. All of these extra-Hawaiian locality records are new, and, with the exception of Samoa, are in southeastern Polynesia.

Hostplants: *Acacia confusa*, *Acacia koa*, sugarcane, sweet potato.

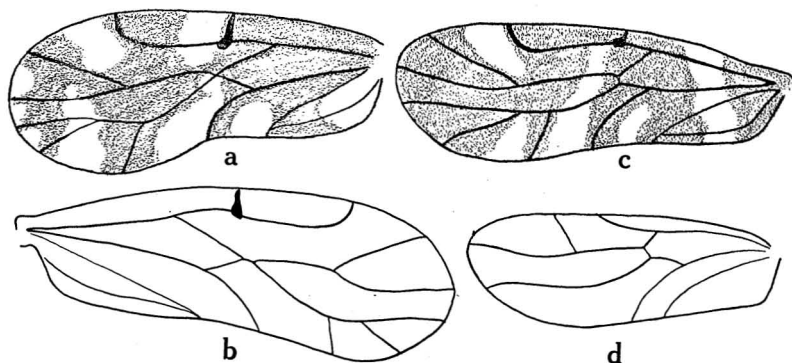


Figure 129—Wings of *Ectopsocus*: a, fore wing of *E. perkinsi* Banks; b, fore wing of *E. hawaiiensis* Enderlein; c-d, fore and hind wings of *E. fullawayi* Enderlein.

***Ectopsocus hawaiiensis* Enderlein (fig. 129, b).**

*Ectopsocus hawaiiensis* Enderlein, 1913:356.

Oahu (type locality: Honolulu).

Immigrant. I collected specimens of this species at light at the Naval Station, Tutuila, Samoa, in 1940 (new record) and I have seen four examples taken by F. X. Williams in the quarantine room of the Hawaiian Sugar Planters' Experiment Station in Honolulu and labeled "Philippines ???." Swezey and Usinger collected it on Guam.

This is one of our commonest species and has been found on *Ficus*, pineapple, smutty "noni" and moldy *Pandanus* mats, and I have recently examined a series of specimens reared from old pods of pigeon peas by Swezey and have seen it commonly under webbings on *Ficus bengalensis* where it becomes especially abundant when the young of the aphid *Thoracaphis* are produced in winter.

***Ectopsocus perkinsi* Banks (fig. 129, a).**

*Ectopsocus perkinsi* Banks, 1931:438, pl. 7, fig. 4.

Oahu (type locality: "Honolulu Mts. 1500 ft.").

Immigrant. I collected what appears to be this species on Viti Levu, Fiji, in 1938 (new record).

F. X. Williams found some examples in new garden compost.

#### Family HEMIPSOCIDAE Pearman, 1935

One genus from our fauna is placed here. If it were not for its setose fore wing veins and the fact that media in the fore wing has only one branch so that there are only two marginal cells beyond the cubital cell, it might run to the Psocidae. Banks places the genus in the Caeciliidae, and Karny places it in Hemipsocini and assigns it to the Psocidae.

Genus **HEMIPSOCUS** Selys, 1872

**Hemipsocus roseus** (Hagen) (figs. 122, b-c; 128; 130, a).

*Psocus roseus* Hagen, 1859:203.

*Epipsocus roseus* (Hagen) McLachlan, 1872:78.

*Hemipsocus roseus* (Hagen) Banks, 1931:438, pl. 8, fig. 1; pl. 9, figs. 1, 2 (eggs).

Oahu.

Immigrant. Ceylon, Philippines, Central America, West Indies. First recorded from Honolulu by Banks in 1931 from specimens collected a few years previously.

This is one of the most distinct of our immigrant species. The large, conspicuous setae on the fore wing veins arise from conspicuous dark dots which give the wings a characteristic spotted appearance. In life the integument is almost white, but the sides of the body, including the head, thorax and abdomen, are speckled with pink blotches, and the eyes are greenish.

This insect has been taken from sugarcane and other plants; it is common beneath the dried leaf-sheaths of sugarcane. Williams (1931:86) says, "The female lays a group of tiny eggs and they are protected by a convex cover that greatly resembles a speck of mud. One specimen was reared from an egg, the life cycle occupying about 31 days. The adults may live for many weeks."

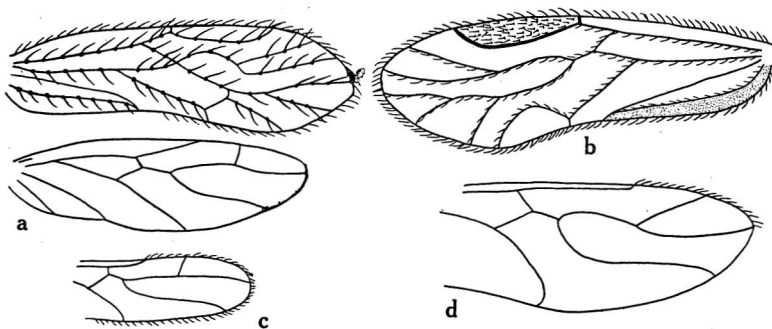


Figure 130—Venation of some psyllid wings: a, fore and hind wings of *Hemipsocus roseus* (Hagen); b, fore wing of *Caecilius analis* Banks; c, distal part of hind wing of *Caecilius analis* Banks for comparison with d; d, the same of *Palistreptus montanus* (Perkins) to show differences in marginal setae.

Family **ELIPSOCIDAE** Pearman, 1936:60

Two endemic genera are placed here. Some authors include them with the Caeciliidae, and Karny placed them in the Elipsocinae of the Lachesillidae. Both *Kilauella* and *Palistreptus* have the apex of cubitus in the hind wing characteristically curved into the wing margin as illustrated (figs. 131, 132). These genera have three-segmented tarsi and the fore wing veins and margins are setose.



## KEY TO THE GENERA OF ELIPSOCIDAE FOUND IN HAWAII

1. Fore wing with radial sector and media not fused into a distinct common vein, but joined by a short transverse cross-vein (fig. 131, g) or just touching one another and forming a simple X (fig. 131, h)..... **Kilauella** Enderlein.
2. Fore wing with radial sector and media completely fused to form a single, short, distinct, longitudinal vein between their points of contact and their points of divergence which is several times as long as breadth of a vein (fig. 132).....  
..... **Palistreptus** Enderlein.

Because of the fusion of radial sector and media in the fore wing, *Palistreptus* might be confused with *Caecilius* by one unfamiliar with the group, but the three-segmented tarsi, the fact that in the hind wing  $R_{2+3}$  is more than one-half as long as  $R_{4+5}$  instead of only about one-fourth as long, the non-setose hind margin of the hind wing, together with other characters, will all serve to distinguish the two genera easily.

Genus **KILAUELLA** Enderlein, 1913:357

In *Fauna Hawaiiensis* Perkins described 10 endemic species in the genus *Elipsocus*. All these species have since been removed from that genus by Enderlein and are now placed in either *Kilauella* or *Palistreptus*. These two genera are known only from the Hawaiian Islands, but their affinities appear to be with other Polynesian psocids.

Enderlein (1920) considered that *Kilauella* consisted of a single species with five varieties, and he reduced two of Perkins' species to synonymy.

At least one of the species of *Kilauella* shares with *Palistreptus* (see below) an unusual and confusing tendency toward variation in wing venation. The normal condition in the fore wing of *Kilauella* is that areola postica is completely free from media. However, on the specimens of *K. micramaura* which I have seen, areola postica is joined to media in the same way that it is in the Hawaiian *Psocus*. Enderlein (1920, fig. 10) illustrates a specimen which he called *K. micramaura* which does not have areola postica fused with media. Perkins, in his original description, stated that areola postica was fused with media and that "This minute species is easily distinguished by the form of the area postica, and the nervuration is not that of the genus *Elipsocus* at all. Nevertheless I have not cared to separate it, because of the fact that other species have a tendency towards a similar nervuration, e.g. *E. inconstans* . . ." (For *E. inconstans*, see *Palistreptus inconstans*, below.) Banks (1931:437), noting the discrepancy between Perkins' original description and Enderlein's figure, said, "I give a figure of my specimen which agrees closely with Perkins'; the figure of Enderlein is of another species; Perkins distinctly mentions the union of areola postica with media." Banks' figure agrees in venation with the specimens I have seen, including material in Perkins' own collection and that of the *Fauna Hawaiiensis*. However, it appears to me that Enderlein's figures have been mislabeled (see discussion below under *inaequifusca* for my reasons).

If the venation of *Kilauella micramaura* were proven to be constant for the fusion of areola postica and media (and it has not yet been demonstrated to be otherwise, for all of the specimens studied have it constant), then I believe that a new genus would be necessary for the species. I believe we can see here a genus or genera "in the making." As it is, *Kilauella micramaura* probably cannot be assigned to the genus *Kilauella* on the basis of wing venation unless the usually diagnostically important character of the areola postica is ignored.

The following table of identification is a tentative key to the species (in the sense of Perkins). I have not seen any specimens of *K. criniger*, which was described by Perkins from a unique, and have been unable to place it in the key. According to Perkins, it is much like *K. psylloides*, but has some definite fuscous markings.

In addition to the following species, I have studied other forms which appear to be distinct new species.

#### KEY TO THE SPECIES OF KILAUELLA

(*K. criniger* [Perkins] omitted)

1. Hind wing with vein  $R_{2+3}$  almost vertical (as in fig. 131, e); fore wing with vein  $R_{2+3}$  diverging at a point close above origin of vein  $M_2$  and areola postica completely fused with media (fig. 131, d) ..... **micramaura** (Perkins).  
Hind wing with vein  $R_{2+3}$  very oblique (fig. 131, a); fore wing with veins  $R_{2+3}$  and  $R_{4+5}$  diverging at a point closer to origin of vein  $M_3$  than to  $M_2$  and areola postica not fused with media (fig. 131, a) ..... 2
- 2(1). Fore wing with areola postica just touching or very nearly touching media—but not fused with it—as in figure 131, f ..... **frigida** (Perkins).  
Fore wing with areola postica completely free from media (separated by a distance at least twice as great as thickness of media) (fig. 131, a) ..... 3
- 3(2). Pterostigma of fore wings with a distinct pink spot of variable size at base and apex, or entire pterostigma pink... ..... **erythrosticta** (Perkins).  
Pterostigma without pink coloration (excepting an occasional faint tinge of pink at base only, but never at apex.. 4
- 4(3). Fore wings with veins R and M touching one another below base of pterostigma and there forming a simple X (fig. 131, h) ..... **debilis** (Perkins).  
Fore wings with veins R and M not touching but connected by a short cross-vein as in figure 131, g ..... 5
- 5(4). Membrane of fore wings almost entirely hyaline, at most only a few parts infusate; areola postica variable, but shaped more like that shown in figure 131, b, than that in figure 131, c. .... **psylloides** (Perkins).  
Membrane of fore wings almost entirely infusate, at most only parts hyaline; areola postica variable, but shaped more like that shown in figure 131, c, than in figure 131, b.. 6

6(5). Fore wings with areola postica uniformly infusate throughout ..... **vinosa** (McLachlan).

Fore wings with at least the basal part of areola postica pale or subhyaline ..... **inaequifusca** (Perkins).

Because I have found among the various species described by Perkins characters adequate enough to enable me to prepare this key, I have not accepted Enderlein's arrangement of the species of this genus. A synopsis of Enderlein's classification is given following the main list of species.

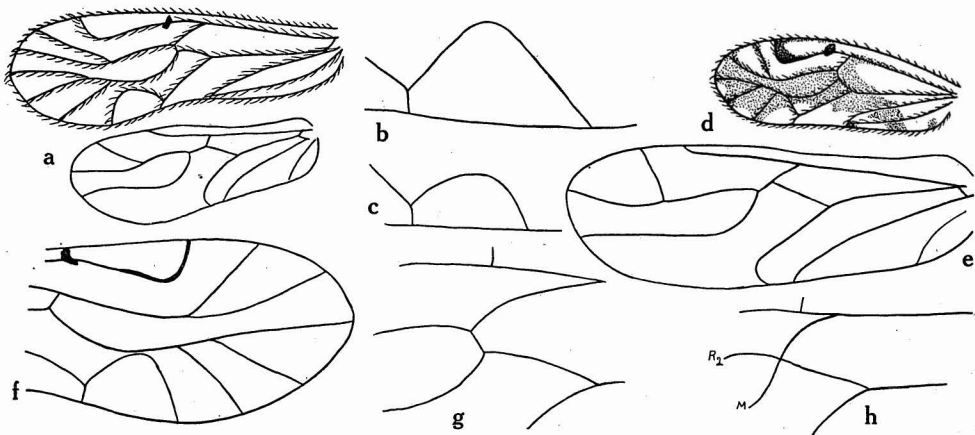


Figure 131—Details of *Kilauella* species: a, fore and hind wings of *K. vinosa* (McLachlan); b, areola postica of *K. psylloides* (Perkins); c, areola postica of *K. inaequifusca* (Perkins); d, fore wing of *K. micramaura* (Perkins); e, hind wing of *K. micramaura* (not to same scale as d); f, apical part of fore wing of *K. frigida* (Perkins) to show formation of areola postica, setae omitted; g, formation of junction of R and M in fore wing of *K. psylloides* (Perkins); h, the same for *K. debilis* (Perkins).

### ***Kilauella criniger* (Perkins).**

*Elipsocus criniger* Perkins, 1899:85.

*Kilauella criniger* (Perkins) Enderlein, 1913:357.

Endemic. Hawaii (type locality: Kona, 2,000 feet).

I have not seen authentic specimens of this species. Perkins said that it was an ally of *K. psylloides*. Enderlein (1920:456) reduced it to a synonym of *K. psylloides*. Specimens thought to be this species were taken by Swezey on *Suttonia* and *Sophora*.

### ***Kilauella debilis* (Perkins) (fig. 131, h).**

*Elipsocus debilis* Perkins, 1899:85.

*Kilauella debilis* (Perkins) Enderlein, 1913:357.

*Kilauella vinosus* variety *debilis* (Perkins) Enderlein, 1920:455, fig. 12.

Endemic. Oahu (type locality: Waianae Mountains, above 2,000 feet).

This form appears to me to be extremely close to *K. psylloides*, and it may be the same. The type must be restudied before a decision can be reached, however. Banks (1931:437) said, "Fully distinct from *K. vinosa*."

**Kilauella erythrosticta** (Perkins).

*Elipsocus erythrosticta* Perkins, 1899:86.

*Kilauella erythrosticta* (Perkins) Enderlein, 1913:357. Genotype of *Kilauella*.

*Kilauella vinosa* variety *erythrosticta* (Perkins) Enderlein, 1920:454, fig. 9.

Endemic. Oahu, Hawaii (type locality: Kona, 2,000 feet).

I have seen specimens of this beautiful species taken from *Elaeocarpus*, *Pisonia*, *Antidesma*, *Pelea*, and *Neowawraea*. The pink color of the pterostigma is striking and diagnostic.

**Kilauella frigida** (Perkins) (fig. 131, f).

*Elipsocus frigidus* Perkins, 1899:87.

*Kilauella frigida* (Perkins) Enderlein, 1913:357.

Synonymized with *K. micramaura* by Enderlein, 1920:455.

Endemic. Hawaii (type locality: Mount Hualalai, 8,000 feet).

**Kilauella inaequifusca** (Perkins) (fig. 131, c).

*Elipsocus inaequifuscus* Perkins, 1899:86.

*Kilauella inaequifusca* (Perkins) Enderlein, 1913:357.

*Kilauella vinosa* variety *inaequifusca* (Perkins) Enderlein, 1920:456, fig. 11 (10 ?).

Endemic. Maui (type locality: Mount Haleakala, 5,000 feet).

Enderlein's figure is not of this species, but it seems to represent *K. micramaura*. It appears likely to me that the names attributed to figures 10 and 11 of Enderlein's plate 6 have been confused and should be transposed.

**Kilauella micramaura** (Perkins) (fig. 131, d-e).

*Elipsocus micramaurus* Perkins, 1899:87.

*Kilauella micramaura* (Perkins) Enderlein, 1913:357.

*Kilauella vinosa* variety *micramaura* (Perkins) Enderlein, 1920:455, fig. 10.

Endemic. Oahu, Hawaii (type locality: Kona, 4,000 feet).

This species has been collected from *Metrosideros* and *Gouldia*, and I have seen an example taken by Swezey from fruit of the Sabal palmetto in Honolulu—the only record I have for the occurrence of the species outside of the forest.

Banks (1931:437, pl. 7, fig. 7) considered this to be a distinct species, and he figured his specimen. He considers Enderlein's figure as that of another species, and he appears to be correct in that assumption. I have seen several specimens of this species, and none of them agrees with Enderlein's figure. However, as mentioned above, there may be some confusion in the labeling of Enderlein's figures 10 and 11 (see discussion under *K. inaequifusca*).

**Kilauella psylloides** (Perkins) (fig. 131, b, g).

*Elipsocus psylloides* Perkins, 1899:85.

*Kilauella psylloides* (Perkins) Enderlein, 1913:357.

*Kilauella vinosa* variety *psylloides* (Perkins) Enderlein, 1920:456.

Endemic. Oahu, Maui, Hawaii (type locality not specifically designated by Perkins), Midway (?).

This species has been found on *Cheirodendron*, *Xylosma*, *Pelea* and *Santalum*. It appears to me that this may be only a form of *debilis*.

**Kilauella vinosa** (McLachlan) (fig. 131, a).

*Elipsocus vinosus* McLachlan, 1883:229. Perkins, 1899:86.

*Kilauella vinosa* (McLachlan) Enderlein, 1913, 357; 1920:453, fig. 8.

Endemic. Maui, Hawaii (type locality not specifically designated by Perkins). Recorded from *Suttonia* and *Styphelia* (*Cyathodes*).

I have seen specimens from Maui and Hawaii only, but Perkins (1899:86) said that it occurred on "many and probably all of the islands, in the forests."

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According to Enderlein's opinion (1920), the arrangement of the genus *Kilauella* would be as follows:

**Kilauella vinosa** (Perkins) Enderlein.

*Kilauella vinosa* variety *erythrosticta* (Perkins) Enderlein.

*Kilauella vinosa* variety *micramaura* (Perkins) Enderlein.

*Kilauella frigidus* (Perkins); synonymy by Enderlein, 1920:455.

*Kilauella vinosa* variety *debilis* (Perkins) Enderlein.

*Kilauella vinosa* variety *inaequifusca* (Perkins) Enderlein.

*Kilauella vinosa* variety *psylloides* (Perkins) Enderlein.

*Kilauella criminiger* (Perkins); synonymy by Enderlein, 1920:456.

Enderlein may be more correct in his classification of the group than Perkins, but I believe that a much more detailed study based upon longer series of specimens and including critical examination of the holotypes and the genitalia of every form

is essential before anyone will be in a position to show the true condition existing in this group. Some of these forms appear to be fully distinct species, and, moreover, their appearance in the field certainly leads one to believe that several to many species are involved here.

### Genus **PALISTREPTUS** Enderlein, 1920:457

This genus is a close ally of *Kilauella* and appears to me to be but a slightly differentiated offshoot group of *Kilauella*. It might be better to consider this group as only a subgenus of *Kilauella*. The fusion of the radial sector and media in the fore wings is somewhat variable. Some specimens have the single vein formed by this fusion shorter on one wing than on the other. I have seen some specimens of *Kilauella* that have a tendency toward this type of venation, but none that has it so completely developed. Most specimens of both of the species included here are larger than most of the species of *Kilauella* and to the naked eye they more nearly resemble species of *Psocus*. The fused section of the radial sector and media in the fore wings resembles the structure of *Caecilius*, and this group might be confused with *Caecilius*. However, the three-segmented tarsi alone will readily distinguish *Palistreptus*. In this genus, too, the hind wings do not have the hind margins setose as in *Caecilius* (see fig. 130). They are true forest insects.

### KEY TO THE SPECIES OF PALISTREPTUS

1. Fore wing with areola postica partially or entirely infusate; infuscations of wing membrane numerous, distinct, usually quite dark and giving wing a conspicuously speckled and maculate appearance; postclypeus coarsely reticulate and dull ..... **inconstans** (Perkins).
2. Fore wings with areola postica hyaline, never distinctly infusate; infuscations of wing membrane faint and comparatively few, wing faintly spotted, but not conspicuously and contrastingly speckled or maculate; postclypeus finely alutaceus and moderately shiny ..... **montanus** (Perkins).

**Palistreptus inconstans** (Perkins) (figs. 132; 133, a-f).

*Elipsocus inconstans* Perkins, 1899:84.

*Kilauella inconstans* (Perkins) Enderlein, 1913:307.

*Palistreptus inconstans* (Perkins) Enderlein, 1920:457, figs. 14-15. Genotype.

Endemic. Kauai, Oahu, Molokai, Maui, Lanai, Hawaii (type locality not designated in original descriptions).

This species has been found on *Metrosideros* and other forest trees and on Jerusalem cherry.

Perkins chose a good name for this species—it is unusually variable. In his original description, Perkins (1899) said,

The area postica is sometimes free, with a distinct space between it and the inner branch of the cubitus, but sometimes its vertex touches (or is connected by an excessively short transverse nervule with) that branch. In the latter case a closed discoidal area is formed and the examples have no longer the nervuration of the genus. This variation is exhibited by examples of the most different superficial appearance, as well as in those of similar general aspect, and the nervuration on the two sides of the same insect may be markedly different, so that it is evidently in a very unstable condition. Examples from the most widely separated islands of the group show analogous variation.

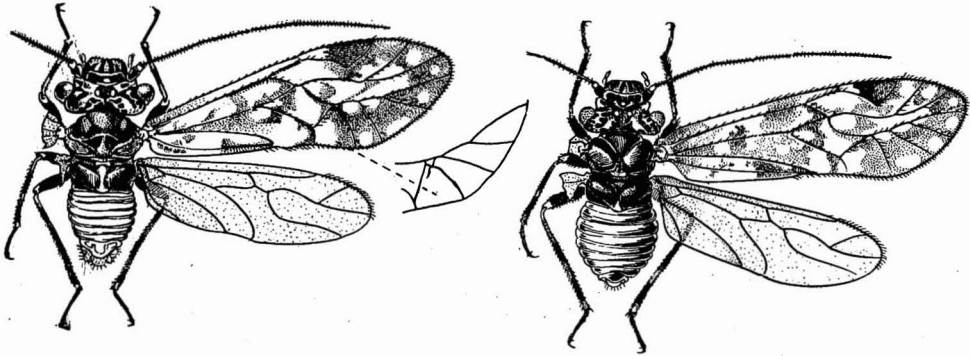


Figure 132—A pair of *Palistreptus inconstans* (Perkins) from Kona, Hawaii, 4,000 feet, from the type series. (Abernathy drawings.) I have sketched an insert figure between the two to show a variation of venation in another example.

I have made some camera lucida sketches from several specimens collected by Perkins to illustrate the confusing variability of the areola postica. Most of the specimens examined have the areola postica free, and this appears to be the "normal" condition. On some examples the sides of the front of the head are conspicuously angulate or actually produced as a distinct tubercle between the eyes and the antennae. I have not seen such protuberances on any of the specimens of *Palistreptus montanus* examined.

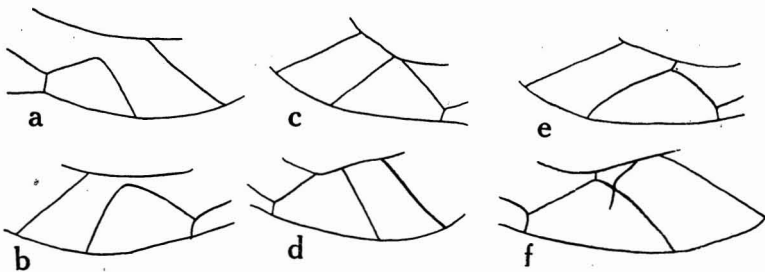


Figure 133—Sketches to show variation in form of areola postica of *Palistreptus inconstans* (Perkins); a, the "normal" form; b, another example; c-d, right and left wings of one individual; e-f, right and left wings of another individual.

**Palistreptus montanus** (Perkins) (fig. 130, d).

*Elipsocus montanus* Perkins, 1899:83.

*Kilauella montana* (Perkins) Enderlein, 1913:359.

*Palistreptus inconstans* variety *montanus* (Perkins) Enderlein, 1920:458, fig. 16.

Endemic. Maui (type locality: Mount Haleakala, 5,000 feet).

All the specimens that I have seen may be distinguished readily from typical *inconstans*. None of the dozen examples studied has any tendency toward variation of areola postica as has *inconstans*. I have been unable to find any differences in the male genitalia between this form and *inconstans* in the dissections I have made of one specimen of each form, but perhaps my preparations have not been adequate.

#### Family PSOCIDAE Leach, 1815

This family contains the largest of the Hawaiian psocids. The two-segmented tarsi, well-developed pterostigma, naked fore wing veins, the fact that areola postica is joined to media and other characters will serve to distinguish the forms present in Hawaii. However, there are certain aberrant and confusing species of Elipsocidae, namely *Kilauella micramaura* and *Palistreptus inconstans*, which vary in their wing venation and may be confused with this family. Each of these species has individuals in whose fore wings the areola postica may be fused with media just as in *Psocus*. However, these species have the wing veins distinctly setose and their tarsi are three-segmented instead of two-segmented as they are in *Psocus*.

Perkins, in *Fauna Hawaiiensis*, described 14 species, none of which was figured. to that genus and it is not figured. I have not seen it, and I cannot place it as to genus or species in this system. It is, however, placed tentatively at the end of *Psocus*.

#### Genus PSOCUS Fabricius, 1798

This cosmopolitan genus contains the largest species of Hawaiian psocids—some of them measure a centimeter in expanse. Also, in numbers of species described, this genus is the largest. All of the species recorded are endemic to these islands and are denizens of the forests where they can commonly be collected from shrubbery, dead branches, mossy limbs, trunks of trees and similar situations. In some localities they are among the commonest of native insects and occur in swarms.

Perkins, in *Fauna Hawaiiensis*, described 14 species, none of which was figured. In 1920, Enderlein reduced Perkins' species to two full species including six varieties—the other six species of Perkins were considered synonyms. Enderlein gave colored illustrations of seven of these forms. Supposedly, Enderlein studied Perkins' types, but there is reason to believe that he made certain errors and did not have the actual holotype specimen before him in every case. Banks, who has available some of Perkins' original material (from the *Fauna Hawaiiensis* collection) at the Museum of Comparative Zoology at Harvard, does not agree with Enderlein's synonymy. In a box of miscellaneous psocids sent to the Bishop



Museum by Dr. Perkins, there appears the following note written by Perkins: "NB. The named specimens of psocids here are not altogether to be relied on. The *types* in B[ritish] Mus[eum] were all named and labeled as such by myself, but the collection in general was blocked up later by a boy who in some cases at least to my knowledge made errors when he did this and put on the printed labels, after I had returned to Hawaii." One can understand, therefore, that errors might easily be made when examining *Fauna Hawaiiensis* psocid material other than the actual types labeled by Perkins. However, Enderlein definitely states that each of his figures of *Psocus* was made "Nach der Type."

It may be that Enderlein's interpretation is more nearly correct than that of Perkins. However, I believe that a more detailed study of this group with a careful re-examination of the holotypes and a study of adequate series is essential before we can hope to understand this endemic complex. Perkins had the great advantage of knowledge gained by studying the insects in the field, and I must say that various forms which I have collected and others which I have studied certainly appear to be distinct species. It is probable that a study of the genitalia will reveal some useful data. I have tried to make a key to the species from the Bishop Museum's share of the *Fauna Hawaiiensis* material, but I have failed to find usable external characters in my cursory study. I have, however, been handicapped by not having a complete set of the species available. Evidently most of the "species" have unusually variable color patterns in the wings. In some series, hardly any two specimens agree as to color pattern. The drawings of the wings of the types, which were made after this text was completed, will aid in the identification of the various forms.

The 14 species are listed first as they were described by Perkins, and, following this list, the arrangement proposed by Enderlein is given in synoptic form.

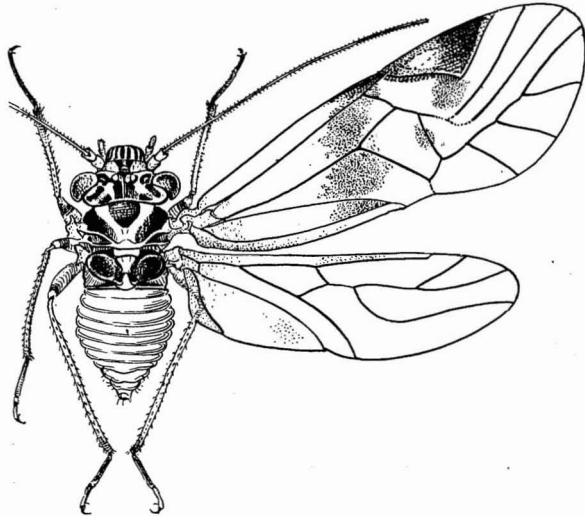


Figure 134—*Psocus haleakalae* Perkins. (Abernathy drawing.)

**Psocus distinguendus** Perkins (fig. 135, a).*Psocus distinguendus* Perkins, 1899:80.*Clematostigma distinguendum* (Perkins) Enderlein, 1913:355.

Endemic. Molokai (type locality: "Molokai Mts., 3,000 ft., June, 1896"), Lanai, Maui, Hawaii.

Hostplants: *Acacia koa*, *Coprosma*, *Metrosideros* and *Sadleria*.

**Psocus haleakalae** Perkins (figs. 134; 135, b).*Psocus haleakalae* Perkins, 1899:77.*Clematostigma haleakalae* (Perkins) Enderlein, 1913:355.

Endemic. Maui (type locality: Mount Haleakala, 5,000 feet, May, 1896), Hawaii.

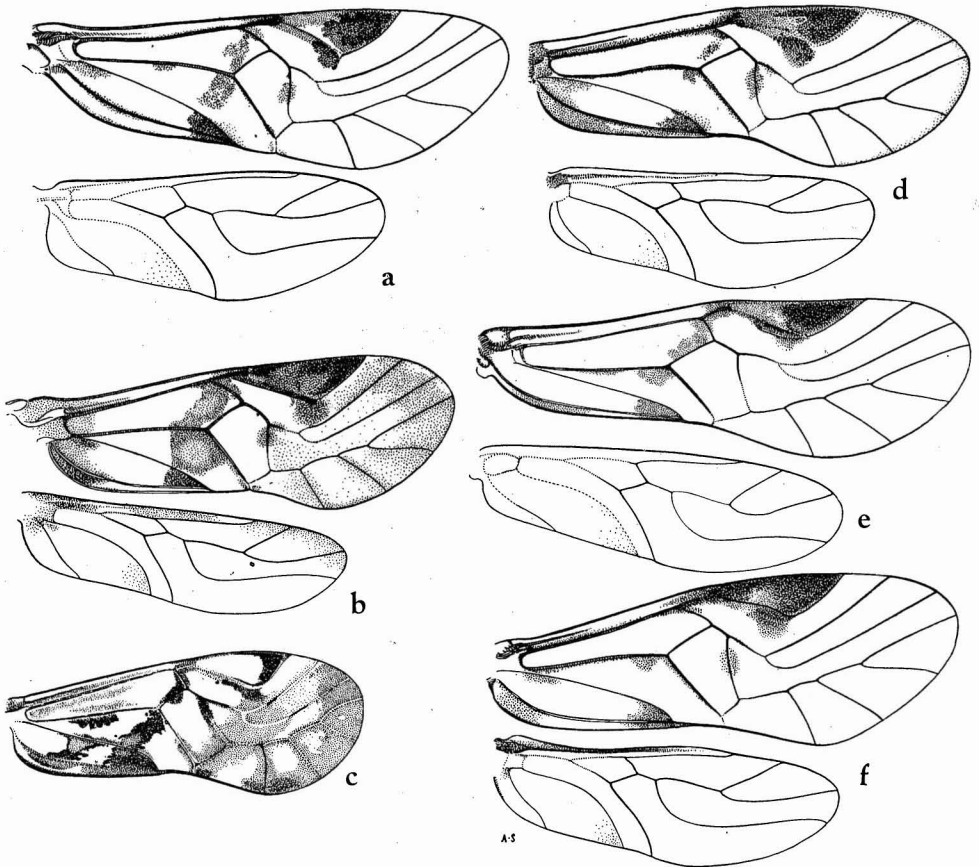


Figure 135—Wings of holotypes of *Psocus*: a, *P. distinguendus* Perkins, male; b, *P. haleakalae* Perkins, male; c, *P. heterogamias* Perkins, male; d, *P. hualalai* Perkins, male; e, *P. kanaiensis* Perkins, male; f, *P. konae* Perkins, male. (Drawn at the British Museum of Natural History by Smith.)

**Psocus heterogamias** Perkins (fig. 135, c).

*Psocus heterogamias* Perkins, 1899:82.

*Clematostigma heterogamias* (Perkins) Enderlein, 1913:355.

Endemic. Oahu (type locality: Waianae Mountains, April, 1892).

Hostplant: *Elaeocarpus*.

**Psocus hualalai** Perkins (fig. 135, d).

*Psocus hualalai* Perkins, 1899:79.

*Clematostigma hualalai* (Perkins) Enderlein, 1913:355.

Endemic. Hawaii (type locality: Mount Hualalai, "about 8000 feet," August, 1892).

**Psocus kauaiensis** Perkins (fig. 135, e).

*Psocus kauaiensis* Perkins, 1899:79.

*Clematostigma kauaiensis* (Perkins) Enderlein, 1913:355.

Endemic. Kauai (type from 4,000 feet?), Oahu, Maui.

Hostplant: *Metrosideros*.

Banks has recorded this species erroneously from the island of Guam (1942:25). I have examined the series of Guam specimens determined by him as this species and find them to be quite distinct although the characters displayed by the wings are remarkably similar. The genitalia afford excellent characters for separating the species. It may also be that the Guam series represents two species instead of one as determined by Banks.

**Psocus konae** Perkins (fig. 135, f).

*Psocus konae* Perkins, 1899:79.

*Clematostigma konae* (Perkins) Enderlein, 1913:355.

Endemic. Hawaii (type locality: Kona, 4,000 feet, 1892).

**Psocus lanaiensis** Perkins (fig. 136, a).

*Psocus lanaiensis* Perkins, 1899:81.

*Clematostigma lanaiensis* (Perkins) Enderlein, 1913:355.

Endemic. Molokai, Lanai (type locality: Koele Mountains, 3,000 feet, February, 1894).

**Psocus molokaiensis** Perkins (fig. 136, b).*Psocus molokaiensis* Perkins, 1899:80.*Clematostigma molokaiensis* (Perkins) Enderlein, 1913:355.

Endemic. Molokai (type locality: 3,000 feet, June, 1896).

Hostplant: *Styphelia* (*Cyathodes*).**Psocus monticola** Perkins (fig. 136, c).*Psocus monticola* Perkins, 1899:82.*Clematostigma monticola* (Perkins) Enderlein, 1913:355.

Endemic. Kauai (type locality. Waimea Mountains, 4,000 feet, 1894).

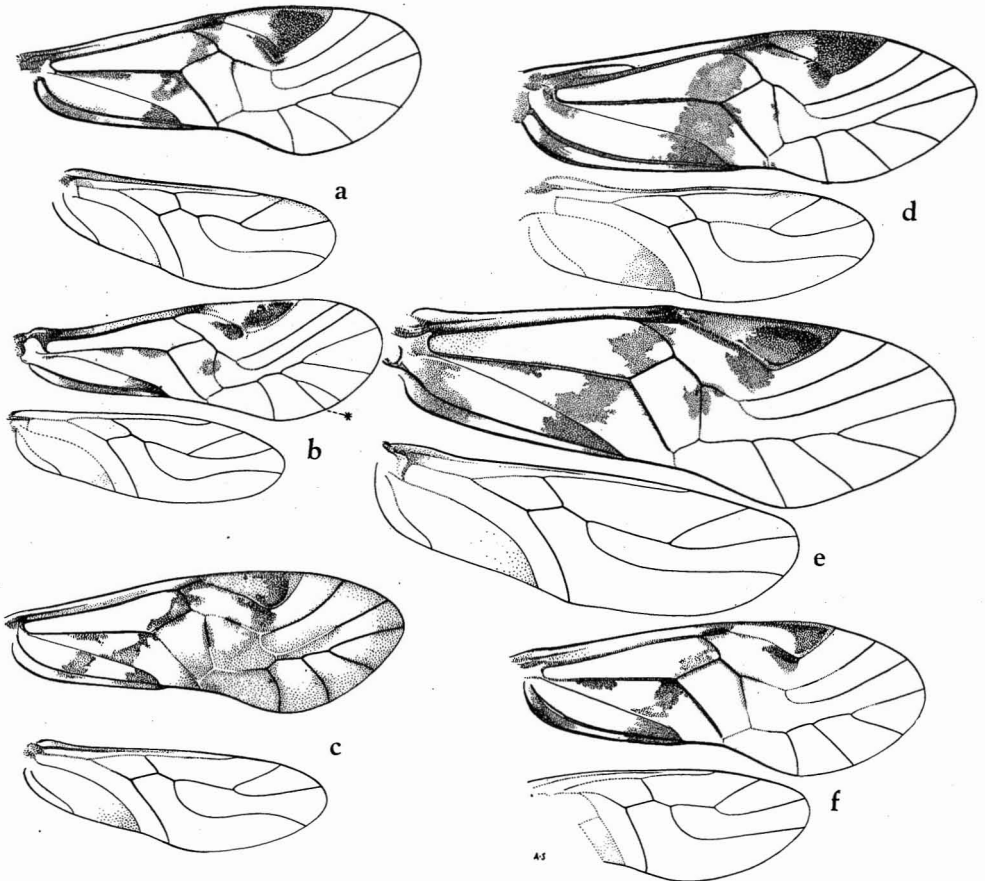


Figure 136—Wings of holotypes of *Psocus*: a, *P. lanaiensis* Perkins, male; b, *P. molokaiensis* Perkins, male (vein marked by asterisk is not forked in left wing); c, *P. monticola* Perkins, male; d, *P. oahuensis* Perkins, female; e, *P. simulator* Perkins, male; f, *P. sylvestris* Perkins, male. (Drawn at the British Museum of Natural History by Smith.)

**Psocus oahuensis** Perkins (fig. 136, d).*Psocus oahuensis* Perkins, 1899:81.*Clematostigma distinguendum oahuensis* (Perkins) Enderlein, 1913:355.

Endemic. Oahu (type locality: Waianae Mountains).

Hostplants: *Acacia koa*, *Pipturus*, *Neowawraea*.**Psocus simulator** Perkins (fig. 136, e).*Psocus simulator* Perkins, 1899:78.*Clematostigma simulator* (Perkins) Enderlein, 1913:355.

Endemic. Maui (type locality: Mount Haleakala, 5,000 feet, October, 1896).

**Psocus sylvestris** Perkins (fig. 136, f).*Psocus sylvestris* Perkins, 1899:81.*Clematostigma sylvestris* (Perkins) Enderlein, 1913:355.

Endemic. Hawaii (type locality: Kona, 4,000 feet, 1892).

Hostplant: *Myoporum*.This species was labeled *Psocus immaturus* Perkins in the *Fauna Hawaiiensis* collection; the type also bears the same name label.**Psocus unicus** Perkins (fig. 137, a).*Psocus unicus* Perkins, 1899:78.*Clematostigma unicus* (Perkins) Enderlein, 1913:355.

Endemic. Maui (type locality: Mount Haleakala, 5,000 feet, May, 1896), Hawaii.

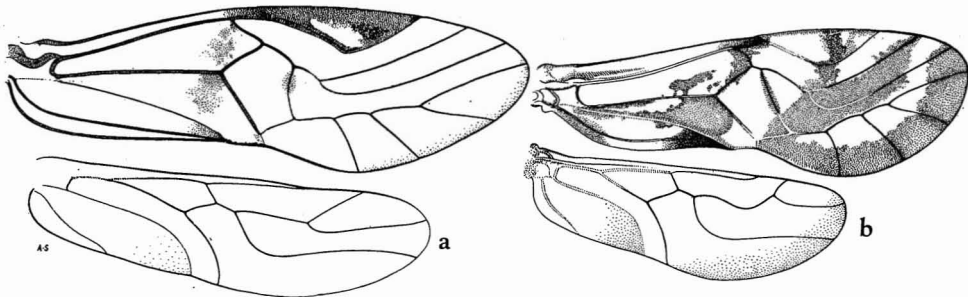


Figure 137—Wings of *Psocus*: a, *P. unicus* Perkins, holotype; b, *P. vittipennis* Perkins, holotype female. (Drawn at the British Museum of Natural History by Smith.)

**Psocus vittipennis** Perkins (fig. 137, b).

*Psocus vittipennis* Perkins, 1899:82.

*Clematostigma vittipennis* (Perkins) Enderlein, 1913:355.

Endemic. Kauai (type locality: Waimea Mountains, 4,000 feet, 1894).

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The following is a synopsis of Enderlein's arrangement of the "species" of Perkins. I have not repeated the *Fauna Hawaiensis* references, the synonymy involving *Clematostigma* or the locality data which have been given in detail above.

**Psocus distinguendus** Perkins. Enderlein, 1920:452, fig. 7.

**Psocus distinguendus** variety **oahuensis** (Perkins) Enderlein, 1920:452.

**Psocus distinguendus** variety **vittipennis** (Perkins) Enderlein, 1920:453.

**Psocus haleakalae** Perkins. Enderlein, 1920:449, fig. 1.

*Psocus unicus* Perkins; synonymy by Enderlein, 1920:449.

**Psocus haleakalae** variety **hualalai** (Perkins) Enderlein, 1920:451, fig. 4.

*Psocus simulator* Perkins; synonymy by Enderlein, 1920:451.

**Psocus haleakalae** variety **lanaiensis** (Perkins) Enderlein, 1920:450.

*Psocus sylvestris* Perkins; synonymy by Enderlein, 1920:451, fig. 3.

*Psocus heterogamias* Perkins; synonymy by Enderlein, 1920:451.

**Psocus haleakalae** variety **molokaiensis** (Perkins) Enderlein, 1920:451, fig. 5.

*Psocus konae* Perkins; synonymy by Enderlein, 1920:451.

*Psocus kauaiensis* Perkins; synonymy by Enderlein, 1920:451, fig. 6. Banks, 1931:437, considers this to be a good species.

**Psocus haleakalae** variety **monticola** (Perkins) Enderlein, 1920:450, fig. 2.

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## SPECIES INCERTAE SEDIS

The following species does not belong to the genus to which it was assigned, and in the absence of either specimen or illustration I am unable to place it.

**(Stenopsocus ?) pulchripennis** Perkins, 1899:83.

Endemic. Hawaii (type locality: Mount Hualalai, 8,000 feet).

Known only from the unique, mutilated holotype in the British Museum.

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## Order MALLOPHAGA Nitzsch, 1818

(mallos, lock of wool; phagein, to eat)

*Aptera* Linnaeus, 1758, in part.

*Parasita* Latreille, 1802, in part.

*Anoplura*, family *Nirmides* Leach, 1815.

*Mallophaga* Nitzsch, 1818.

*Mandibulata* Latreille, 1825.

*Lipoptera* Shipley, 1904.

### Biting Lice

Body elongate to rotund, depressed, soft, integument tough. Head large, exposed, usually broader than prothorax, porrect; mouth parts on underside, fitted for biting; labrum well developed; mandibles large, tridentate; maxillae with single lobes, maxillary "rods" present in some forms, palpi four-segmented or absent; labium with greatly reduced or obsolete palpi; anterior part of oesophagus sclerotized to form the "oesophageal sclerite"; hypopharynx complex, well developed, most forms with associated "rod-like stalks"; antennae three-, four- or five-segmented, shorter than head; eyes reduced; ocelli absent. Thorax with prothorax usually free, but meso- and metathorax united or separated by a suture; with one pair of ventral prothoracic spiracles. Wings or wing rudiments absent. Legs with one- or two-segmented tarsi; tarsi usually with paired claws, but there may be one pair or none. Abdomen apparently nine-segmented in the adult; cerci absent; spiracles on segments three to eight, two to seven or three to seven; male genitalia large, usually with strongly sclerotized parts; female without an ovipositor, vaginal orifice situated behind ventrite seven. Metamorphosis incomplete; eggs cemented singly to feathers or hairs of host; four instars. Non-bloodsucking, ectoparasites of birds and mammals, but principally on birds. Size range from 0.5 mm. to 10.0 mm.

There are more than 2,000 species of biting lice described from all parts of the world. No fossil forms are known.

In contrast to the Anoplura, the members of the Mallophaga do not suck blood, and none is a parasite of man. By far the greatest numbers are ectoparasites of birds. The food of this group of lice consists principally of feathers, dead skin and hair of the host. The injury done by biting lice is largely the result of severe surface irritation. Heavy infestations are known to cause the death of certain hosts. Severe injury can also be done to the feathers, hair or wool of the host. It has been thought that biting lice did not feed upon blood, but studies by Crutchfield and Hixson (1943) show that at least some lice take blood meals regularly. They say (1943:66):

Barbs and barbules of feathers and blood comprise the food of the chicken body louse (*Menacanthus stramineus*) and a species of *Menacanthus* unrecognized, heretofore, as a pest of poultry in the United States. These species obtain blood by gnawing through the epidermis of the skin and rupturing the quills of pinfeathers. The diet of the shaft louse (*Menopon gallinae*) consists of barbs and barbules. The wing louse (*Lipeurus caponis*) feeds on hooklets of the flight feathers; occasionally, barbs and barbules form a part of the diet. The large chicken louse (*Goniocotes gigas*) and the fluff louse, (*Goniocotes hologaster*) feed largely on barbs and to some extent on barbules.

Clay and Meinertzhagen (1943) have summarized the data concerning the transportation of lice from one host to another through the agency of hippoboscids flies. The lice attach themselves to the flies and may be transferred to abnormal hosts. Some lice are able to escape from dead hosts by riding on the flies when they quit the cold host.

This order has received little attention in Hawaii. The only extensive paper on our species is the partial report of Kellogg and Chapman (1902, reprinted 1904; the types of the species described from Hawaii in that paper should be at Stanford University). There has never been an over-all survey. Only one species was recorded from domestic fowl prior to 1927. Perhaps some light could be thrown upon the drepaniid bird problem if an adequate number of species of lice from that avian family were available for study. It is a pity that the lice collected from the native birds by Perkins were not worked up. (See discussion under Mallophaga in chapter 3 of volume 1 for additional comment.)

Lice can be collected easily if birds and mammals are wrapped completely in cotton as soon as killed. The lice on the animals will leave the cold, dead bodies and migrate into the cotton where they will become trapped and die and may later be picked out. The cotton wrapping from each animal may be placed in a paper bag on which data are written and stored for future study by a louse specialist. Bird collectors should keep this in mind.

The hosts listed hereinafter are those reported for Hawaii only, and I have not made a general listing of the hosts of the various species listed from without the islands. A number of the local host records are obviously from straggler specimens—possibly having been transferred from one host to another in collectors' bags.

I have had much difficulty in writing the following outline, not only because of the confused state of mallophagan taxonomy and the lack of certain literature, but because there has been no adequate collection of lice available for study. I have seen Hawaiian specimens of only a few of the commonest species listed. This is probably the most unsatisfactory chapter in this book.

Miss Theresa Clay has given some constructive criticism and has aided me with the text in several places. Dr. E. W. Stafford has been especially helpful with the Philopteridae; his aid in the construction of the key to the genera and his notes on the generic position of various species have been particularly useful in strengthening the work.

## TABULAR ANALYSIS OF THE HAWAIIAN MALLOPHAGA

FAMILY	GENERA	ENDEMIC GENERA	NON- ENDEMIC GENERA	SPECIES	ENDEMIC SPECIES	INDI- GENOUS SPECIES	ADVENTIVE SPECIES
Gyropidae	2	0	2	2	0	0	2
Boopiidae	1	0	1	1	0	0	1
Menoponidae	7	0	7	14	3	5	6
Trichodectidae	3	0	3	5	0	0	5
Philopteridae	19	0	19	30	2(?)	12	16
Totals	32	0	32	52	5(?)	17	30

Percentage of endemism in native group: genera 0 percent; species 28 percent (?).

Percentage of present-day fauna native: 43 percent.

Percentage of present-day fauna adventive: 57 percent.

Average number of species per genus in native group: 1.5.

Average number of species per genus in adventive group: 1.4.

This group is so poorly known that these figures may not be very accurate. Bird lice are generally widespread insects, and this is especially true of those attached to the widely wandering sea and shore birds; such a large percentage of indigenous species is not found in other orders of Hawaiian insects.

## KEY TO THE SERIES OF MALLOPHAGA

1. Antennae clavate or capitate, four- or five-segmented, concealed in ventro-cephalic scrobes; maxillary palpi present, two-, three-, four- or five-segmented; line of division between meso- and metathorax usually distinct.....**Amblycera.**
2. Antennae filiform or seriform, three- or five-segmented, not concealed in ventral scrobes, but normally visible and extended; maxillary palpi absent; meso- and metathorax always fused with dividing suture obsolete.....**Ischnocera.**

## Series AMBLYCERA (Kellogg, 1896)

## KEY TO THE FAMILIES OF AMBLYCERA FOUND IN HAWAII

1. Mid and hind tarsi each with a single claw, or tarsal claws absent; our species on guinea pigs.....**Gyropidae.**  
Tarsal claws paired; not ectoparasites of guinea pigs..... 2
2. Antennae five-segmented; body hairs mostly stiff and spini-  
form; ectoparasites of marsupials and dogs; male genitalia  
with accessory sac .....**Boopiidae.**  
Antennae four-segmented; body hairs fine; ectoparasites of  
birds; male genitalia without accessory sac.....**Menoponidae.**

## Family GYROPIDAE Kellogg, 1908

## The Biting Guinea Pig Lice

This family is endemic to America (principally South America), but a few of the species have become widespread because of the activities of man. Almost all the species of the family (which totaled about 30 in 1924) are restricted to rodents, and only a few species have been found on primates, ungulates and on a sloth.

The eggs of the two species recorded hereafter are laid singly at the bases of the hair on guinea pigs. Ewing (1924:3) said that "The food of both these species consists in part of cutaneous secretions and excretions and in the case of *G. porcelli* of serum in addition. . . ." Sodium fluoride or a 2 to 5 percent rotenone dust is suggested to control these lice.

## KEY TO THE SUBFAMILIES AND GENERA OF GYROPIDAE FOUND IN HAWAII

1. Short, broad species; maxillary palpi four-segmented; tarsal claws developed; meso- and metathoracic legs with femora fitted with a forked and grooved tenaculum for reception of tarsus when closed into it; tarsus with segment two elongate, transversely furrowed. . . . . **Gyropus** of the Gyropinae.
2. Slender species; maxillary palpi two-segmented; tarsi greatly reduced, claws absent; meso- and metathoracic legs with femora and tibiae arcuate and transversely striate. . . . .  
 . . . . . **Gliricola** of the Gliricolinae.

## Subfamily GYROPINAE Ewing, 1924:9

Genus **GYROPUS** Nitzsch, 1818**Gyropus ovalis** Nitzsch.

*Gyropus ovalis* Nitzsch, 1818:304 (I have not confirmed this reference). Ewing, 1924:13, fig. 6. Genotype.

The oval guinea pig louse.

Oahu.

Immigrant. Not recorded heretofore, but I took it in Honolulu in 1944. It is normally found on guinea pigs wherever the host is taken by man.

Host: guinea pig.

## Subfamily GLIRICOLINAE Ewing, 1924:29

Genus **GLIRICOLA** Mjoeberg, 1910**Gliricola porcelli** (Linnaeus).

*Pediculus porcelli* Linnaeus, 1758:611. Ewing, 1924:33, figs. 15, 17; pl. 1, fig. 8. Oahu (and probably on some of the other islands).

Immigrant. Widespread from South America by man. First found by me in Honolulu in 1943 (1944:200).

Host: guinea pig.

### Family BOOPIIDAE Mjoeberg, 1910

#### The Biting Kangaroo Lice

This family is endemic to Australia where its species are ectoparasites of marsupials, with the exception of the species listed below. One species represents the family in Hawaii, and, because it is a parasite of dogs, it has been widely spread artificially. No search has been made for lice on the wallabies and kangaroos introduced into Hawaii, and perhaps other members of this louse family are also established in the Territory.

#### Subfamily BOOPIINAE Harrison and Johnson, 1916:345

#### Genus **HETERODOXUS** Le Souëf and Bullen, 1902

Paine, 1912:359, figs. *a-g*, note.

#### **Heterodoxus spiniger** (Enderlein).

*Menopon spiniger* Enderlein, 1909:80, figured.

*Heterodoxus longitarsus*, of authors, as recorded from dogs.

Oahu (and other islands?).

Immigrant. Widespread; described from South Africa. First recorded from Hawaii by Carpenter in Honolulu in 1933.

Host: dog.

In some regions, this louse is considered a serious pest of dogs and is so abundant as to cause the death of its canine hosts. It has not, to my knowledge, caused much trouble in Hawaii. It has been referred to as *Heterodoxus longitarsus* (Piaget, 1880:504, pl. 41, figs. 7, 7*a-c*), the kangaroo louse, but Werneck (1941:46) has shown that it is distinct.

Control: A dust made from one part sodium fluoride powder and three to five parts ordinary wheat flour by weight, or equal parts powdered derris and flour rubbed thoroughly into the fur is recommended. A 2 to 5 percent rotenone dust may also be useful.

### Family MENOPONIDAE Mjoeberg, 1910

#### KEY TO THE SUBFAMILIES

1. Prothorax much smaller than head; lateral margins of temples rounded ..... **Menoponinae.**
2. Prothorax very large, about as large as head; temples angulate ..... **Ancistroninae.**

## Subfamily MENOPONINAE

## KEY TO THE GENERA FOUND IN HAWAII

1. Ventral side of posterior femora without a condensed patch of setae; second, third, or fourth abdominal sternites without patches of setae or asters of heavy spines..... **Colpocephalum** Nitzsch.
- Ventral side of posterior femora with a condensed patch of setae; second, third or fourth abdominal sternites with a condensed patch of setae and/or an aster of heavy spines on either side ..... 2
- 2(1). Lateral margin of head with a deep emargination just before the eye (ocular emargination)..... **Actornithophilus** Ferris.
- Lateral margins of head not so emarginate, continuous to eye, but a slit or fracture is present in front of eyes in *Menopon* ..... 3
- 3(2). Ventral surface of head with a sclerotized, hook-like process near base of each mandible..... **Eomenacanthus** Uchida.
- Without such processes ..... 4
- 4(3). Forehead with a fracture-like slit in margin near eyes; oesophageal sclerites heavily sclerotized.... **Menopon** Nitzsch.
- Forehead without such a marginal slit..... 5
- 5(4). Second abdominal ventrite with asters of spines; without a conspicuous gular plate..... **Myrsidea** Waterston.
- Second abdominal ventrite without asters of spines; gular plate conspicuously pigmented... **Machaerilaemus** Harrison.

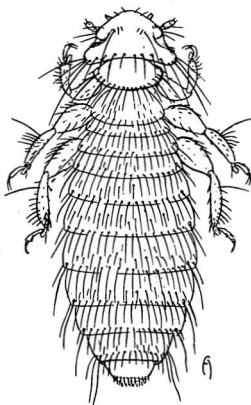
Genus **EOMENACANTHUS** Uchida, 1926:30**Eomenacanthus stramineus** (Nitzsch) (fig. 138).*Liotheum* (*Menopon*) *stramineum* Nitzsch, 1818:300; 1874:291.*Menopon biseriatum* Piaget, 1880:469, pl. 37, fig. 2.*Eomenacanthus biseriatum* (Piaget) Uchida, 1926:31.

Figure 138—*Eomenacanthus stramineus* (Nitzsch), the chicken body louse. (Abernathy drawing.)

The chicken body louse; Hawaiian name: "uku-moa."

Oahu, Molokai, Hawaii.

Immigrant. Cosmopolitan. First recorded from Hawaii by Illingworth from specimens collected on Oahu in 1926.

Hosts: chicken, California valley quail (recorded elsewhere also on turkey, guinea hen and pigeon).

I have records only from Oahu, Molokai and Hawaii, but I assume that it is present on the other islands.

Control may be obtained by the use of sodium fluoride or pyrethrum dusts.

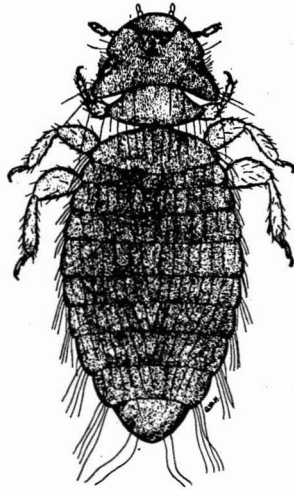


Figure 139—*Menopon gallinae* (Linnaeus), the common hen louse. (After Herrick, 1915.)

#### Genus **MENOPON** Nitzsch, 1818

***Menopon gallinae*** (Linnaeus) (fig. 139).

*Pediculus Gallinae* Linnaeus, 1758:613.

*Menopon pallidum* Nitzsch, 1874:291.

The common hen louse; Hawaiian name: "uku-moa."

Kauai, Oahu. Not recorded from the other islands, but certainly present on poultry throughout the Territory.

Immigrant. Cosmopolitan. First recorded from Hawaii by Illingworth in 1928, but established here much earlier.

Hosts: chicken, duck, guinea hen, pigeon, turkey.

Sodium fluoride dusts give good control.

**Menopon phaeostomum** Nitzsch.*Menopon phaeostomum* Nitzsch, 1866:391.

Oahu.

Immigrant. Cosmopolitan. First collected in the Territory by Illingworth in 1926 at Honolulu.

Hosts: guinea hen and peafowl.

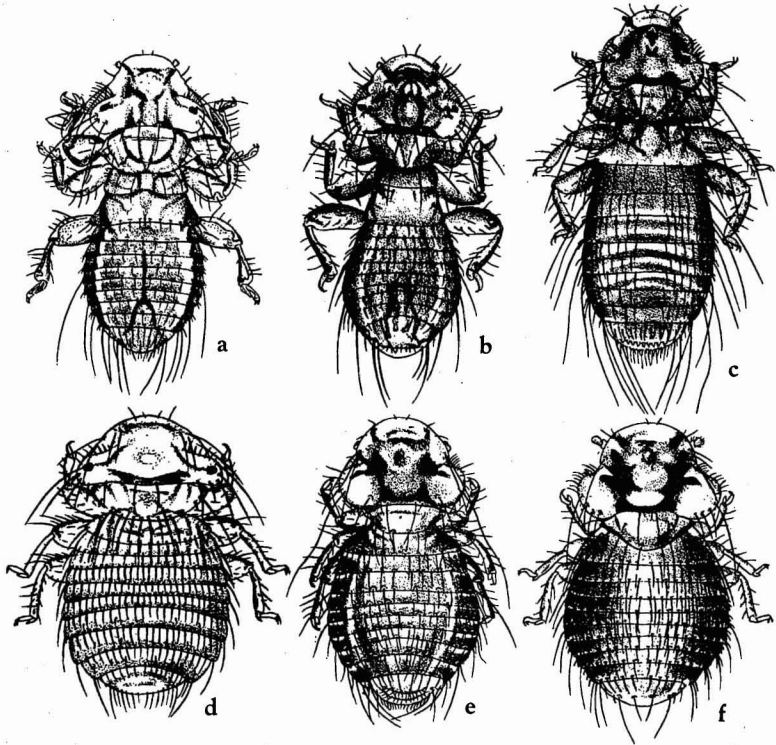


Figure 140—Hawaiian bird lice: a, *Myrsidea conspicua* (Kellogg and Chapman), male; b, *Myrsidea cyrtostigma* (Kellogg and Chapman), male; c, *Myrsidea invadens* (Kellogg and Chapman), female; d, *Machaerilaemus hawaiiensis* (Kellogg and Chapman), female; e, *Colpocephalum brachysomum* Kellogg and Chapman, female; f, *Colpocephalum discrepans* Kellogg and Chapman, female. (Rearranged from Kellogg and Chapman, 1904.)

**Genus MYRSIDEA** Waterston, 1915***Myrsidea conspicua*** (Kellogg and Chapman) (fig. 140, a).*Colpocephalum conspicuum* Kellogg and Chapman, 1902:163, pl. 14, fig. 4; 1904:315, pl. 10, fig. 9.*Myrsidea conspicua* (Kellogg and Chapman) Ferris, 1916:308.

Maui (type material from Kahului and "Pau [?] Olai").

Immigrant (from America?).



Host: *Carpodacus mexicanus obscurus* (house finch).

This species has thus far only been recorded from Maui, but, because it was taken from an introduced bird, I presume that it is most certainly an immigrant species. When the lice are better known, this species will probably prove to be a synonym of some American louse.

**Myrsidea cyrtostigma** (Kellogg and Chapman) (fig. 140, b).

*Menopon cyrtostigmum* Kellogg and Chapman, 1902:165, pl. 15, fig. 3; 1904:318, pl. 10, fig. 12.

*Myrsidea cyrtostigma* (Kellogg and Chapman) Ferris, 1916:308.

Endemic. Maui, Hawaii (type material from both islands).

Hosts: *Chlorodrepanis virens* ("amakihī"), *Himatione sanguinea* ("apapane"), *Vestiaria coccinea* ("iīwi"). All these recorded hosts are endemic Hawaiian birds (Drepaniidae).

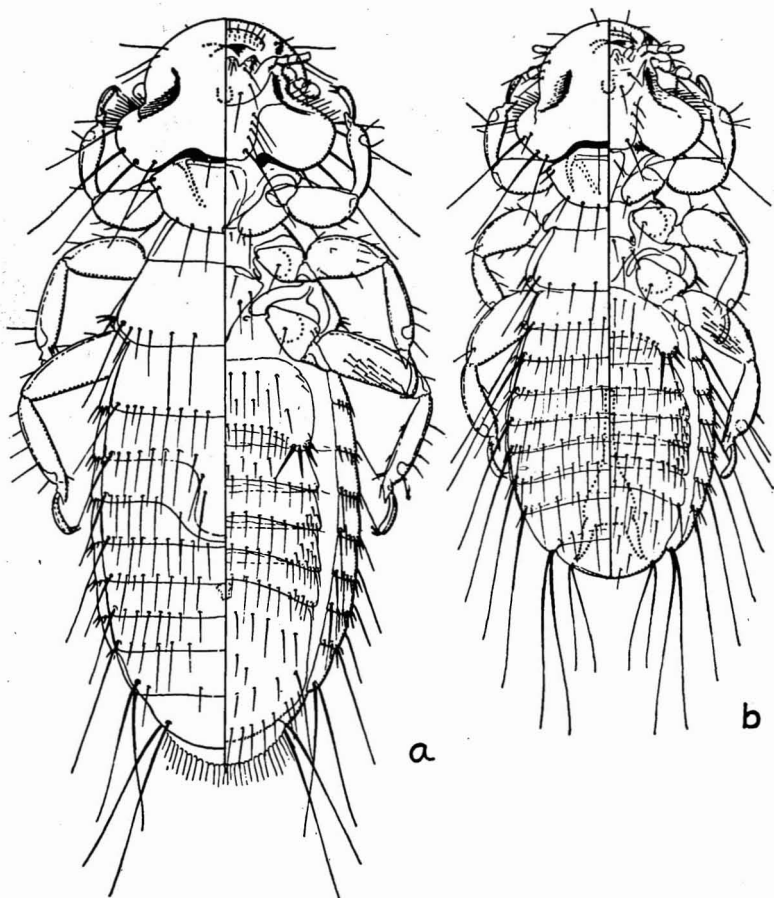


Figure 141—*Myrsidea invadens* (Kellogg and Chapman): a, female; b, male. (After Ferris, 1932:10.)

**Myrsidea invadens** (Kellogg and Chapman) (fig. 140, c; 141, a-b).

*Menopon invadens* Kellogg and Chapman, 1902:167, pl. 15, fig. 5; 1904:320, pl. 10, fig. 14.

*Myrsidea invadens* (Kellogg and Chapman) Ferris, 1916:308; 1932:10, figs. 3, 4.

Molokai, Maui (type locality: Maui).

Immigrant. Recorded from the mynah at Tahiti by Ferris in 1932, but certainly with a much wider distribution, although it is unrecorded elsewhere.

Hosts: *Acridotheres tristis* (mynah), *Streptopelia* (*Spilopelia*, *Turtur*) *chinensis* (Chinese dove) (straggler?).

I have seen records from Maui and Molokai only, but I assume that the species is found wherever the mynah bird is distributed about the islands, but it has not been searched for.

#### Genus **MACHAERILAEMUS** Harrison, 1915

**Machaerilaemus hawaiiensis** (Kellogg and Chapman) (fig. 140, d).

*Menopon hawaiiensis* Kellogg and Chapman, 1902:165, pl. 15, fig. 2; 1904:317, pl. 10, fig. 11.

Endemic. Maui (type locality: Iao Valley).

Host: *Chlorodrepanis virens* (native drepaniid "amakihi").

#### Genus **COLPOCEPHALUM** Nitzsch, 1818

**Colpocephalum brachysomum** Kellogg and Chapman (fig. 140, e).

*Colpocephalum brachysomum* Kellogg and Chapman, 1902:162, pl. 14, fig. 3; 1904:314, pl. 10, fig. 8.

Indigenous (?). Maui (type series from Kahului and Iao Valley).

Hosts: *Asio flammeus sandwichensis* (*Asio accipitrinus*) (the Hawaiian owl), and *Pluvialis dominica fulva* (*Charadrius dominicus fulvus*) (Pacific golden plover). Thompson (1938:206) believes that *Asio* is the true host.

**Colpocephalum discrepans** Kellogg and Chapman (fig. 140, f).

*Colpocephalum discrepans* Kellogg and Chapman, 1902:164, pl. 14, fig. 1; 1904:316, pl. 10, fig. 10.

Indigenous. Maui (type locality: Kahului).

Hosts: *Anous stolidus pileatus* (noddy tern), *Carpodacus mexicanus obscurus* (house finch or linnet).

**Colpocephalum hilensis** (Kellogg and Chapman) (fig. 145, a).

*Menopon hilensis* Kellogg and Chapman, 1902:166, pl. 15, fig. 4; 1904:319, pl. 10, fig. 13.

Endemic. Hawaii (type locality: Hilo).

Host: *Vestiaria coccinea* (the beautiful black and red native drepaniid "iwi").

**Colpocephalum turbinatum** Denny.

*Colpocephalum turbinatum* Denny, 1842:209.

Oahu.

Immigrant. A widespread species. First found in Hawaii in 1945 by members of the armed forces, but not recorded in Hawaiian literature heretofore.

Host: pigeon.

#### Genus **ACTORNITHOPHILUS** Ferris, 1916:303

**Actornithophilus epiphanes** (Kellogg and Chapman) (fig. 145, b).

*Colpocephalum epiphanes* Kellogg and Chapman, 1902:161, pl. 14, fig. 2; 1904:313, pl. 10, fig. 7.

*Actornithophilus epiphanes* (Kellogg and Chapman) Ferris, 1916:304.

Indigenous. Maui (type locality: Kahului).

Host: *Anous stolidus pileatus* (noddy tern).

**Actornithophilus kilauensis** (Kellogg and Chapman) (fig. 145, c).

*Colpocephalum kilauensis* Kellogg and Chapman, 1902:161, pl. 14, fig. 1; 1904:312, pl. 10, fig. 6.

*Actornithophilus kilauensis* (Kellogg and Chapman) Ferris, 1916:304.

Indigenous. Hawaii (type locality: Hilo).

Host: *Heterocelus* (*Heteractitis*) *incanus* (wandering tattler).

#### Subfamily ANCISTRONINAE

#### Genus **ANCISTRONA** Westwood, 1874

**Ancistrona vagelli** (Fabricius).

*Pediculus vagelli* Fabricius, 1787:369.

*Ancistrona gigas* Piaget, 1883:152, pl. 9, fig. 1.

The giant bird louse.

Laysan.

Indigenous. Widespread about the world. First recorded from the Territory by Kellogg and Paine (1910:125).

Host: *Peterodroma leucoptera hypoleuca* (*Aestrelata hypoleuca*) (Bonin Island petrel).

Essig (1929:130) says that this is the broadest known louse.

### Series ISCHNOCERA (Kellogg, 1896)

#### KEY TO THE FAMILIES OF ISCHNOCERA FOUND IN HAWAII

1. Tarsi with single claws; antennae three-segmented (at least in male); ectoparasites of mammals. . . . . **Trichodectidae.**
2. Tarsi with paired claws; antennae five-segmented; ectoparasites of birds . . . . . **Philopteridae.**

### Family TRICHODECTIDAE Kellogg, 1908

This family contains a number of pests which are of major economic importance elsewhere, but they have caused little concern in Hawaii.

#### KEY TO THE GENERA OF TRICHODECTIDAE FOUND IN HAWAII

1. Forehead triangular, almost straight on sides; with fewer than six abdominal spiracles; ectoparasites on cats. . . . **Felicola** Ewing.  
Forehead rounded, broader than long; with six abdominal spiracles; not found on cats. . . . . 2
2. Ectoparasites of goats, sheep, cattle and horses; parameres of male genitalia free; antennae of male and female similar; forehead without hair-groove. . . . . **Bovicola** Ewing.  
Ectoparasites of dogs; parameres of male genitalia united distally; antennae of male and female dissimilar; hair-groove present on forehead. . . . . **Trichodectes** Nitzsch.

### Genus **TRICHODECTES** Nitzsch, 1818

According to Ewing (1929:121), this genus includes, in its restricted sense, those species of the family which have the "antennae three segmented in both sexes but of different shape; temporal lobes without posterior processes; forehead rounded; all of the abdominal segments with pleural plates."

#### **Trichodectes canis** (Degeer).

*Ricinus canis* Degeer, 1778:81, pl. 4, fig. 16.

*Trichodectes latus* Nitzsch, 1838:436. Piaget, 1880:384, pl. 31, fig. 6.

The biting dog louse.

Oahu. Not recorded from the other islands; probably present on all of the main islands, but not yet searched for.

Immigrant. Cosmopolitan. First recorded from Hawaii by Swezey from specimens taken in Honolulu in 1929, but no doubt here at an early date.

Host: dog.

This species has apparently not caused much concern to keepers of dogs in the Territory, for it has been infrequently called to the attention of local entomologists. However, in other localities, severe infestations, especially in young animals, have been reported.

Control: sodium fluoride dusts are effective.

In the late 1860's, Melnikoff and Leuckart found that this louse served as an intermediate host for the common double-pored dog tapeworm, *Dipylidium caninum* (Linnaeus). This discovery is said to be the first to show that an arthropod was involved as an intermediate host of a parasitic worm. The tapeworm is common in dogs and cats and occasionally is recorded from human beings. Most of the human cases have been young children. Human infestation occurs by ingesting an infested louse or flea or crushed parts of these insects. Putting one's fingers in one's mouth after crushing a louse or flea, or handling a pet or allowing a dog, which may have bitten a louse or a flea, to lick one are routes of possible infection. The eggs of the tapeworm are expelled with the host's feces and those which become lodged on the hair or body of the dog or cat may be ingested by the lice. When the tapeworm eggs reach the intestines of the louse, they hatch, and the larval tapeworms bore through the intestines and develop into the cystocercoid stage in the body cavity of the louse. When the cystocercoid stage is reached, the tapeworms are capable of infesting their mammalian hosts. The mature tapeworm reaches a length of about 12 inches. Its mature proglottids are sub-ovate or pumpkin-seed-shaped and have a double reproductive system with a genital pore at about the middle of each side—hence the name double-pored tapeworm.

#### Genus **BOVICOLA** Ewing, 1929:123

This genus can be readily distinguished from *Felicola* because of the shape of its forehead, which is rounded and much broader than long. It was separated from *Trichodectes* principally because the antennae of the males and females are similarly shaped and the shape of the head is different.

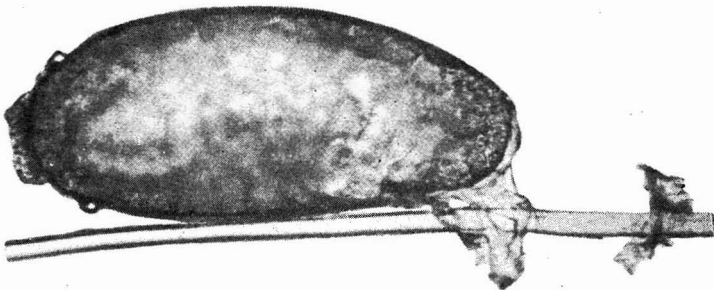
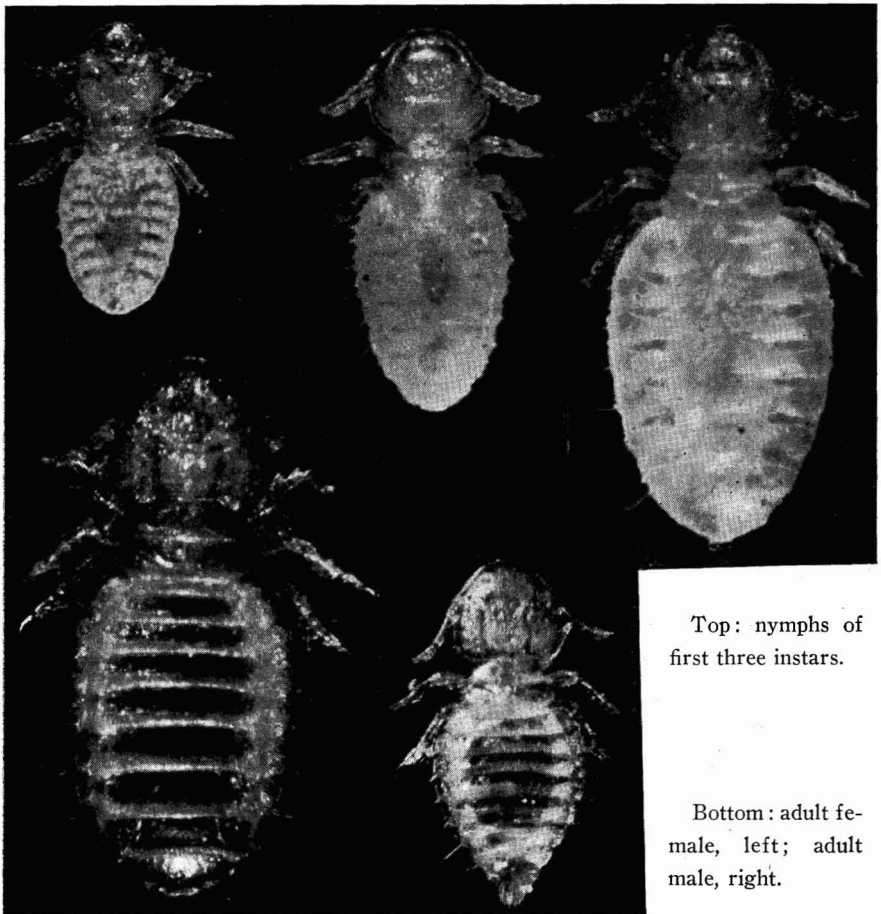


Figure 142—Egg of *Bovicola bovis* (Linnaeus) on a cattle hair. (Photograph kindly furnished by J. G. Matthyse.)

## KEY TO THE SPECIES OF BOVICOLA FOUND IN HAWAII

1. Ectoparasitic on cattle ..... **bovis** (Linnaeus).
2. Ectoparasitic on goats ..... **caprae** (Gurlt).
3. Ectoparasitic on horses ..... **equi** (Linnaeus).
4. Ectoparasitic on sheep ..... **ovis** (Linnaeus).



Top: nymphs of  
first three instars.

Bottom: adult fe-  
male, left; adult  
male, right.

Figure 143—*Bovicola bovis* (Linnaeus), the biting ox louse. (I am indebted to Dr. J. G. Matthyse for supplying the photographs for this plate.)

***Bovicola bovis*** (Linnaeus) (figs. 142, 143).

*Pediculus Bovis* Linnaeus, 1758:611.

*Trichodectes scalaris* Nitzsch, 1818:269 (I have not checked this reference).

The biting ox louse; the cattle red louse.

Molokai, and probably all of the main islands.

Immigrant. Cosmopolitan. First found in Hawaii in 1943 by me on a cow from Molokai examined in Honolulu.

Control: the same as for the biting horse louse, as outlined below. Raw (not boiled) linseed oil applied with a brush is also a good and cheap method of control (keep the treated animal quiet and under cover for at least 12 hours after treatment).

It appears that this species usually reproduces parthenogenetically, but males are known to occur. It is found most abundantly on the back of the host from the neck to the base of the tail. High temperature and high humidity are unfavorable for the development of the louse.

"The instars can readily be distinguished by both head capsule measurements and morphological characters. The first instar nymphs are completely light colored, unchitinized, along the lateral margins of the abdomen. In the second instar the lateral margins of the first visible abdominal segment are partly chitinized, brownish. In the third instar the first visible segment is completely chitinized along the lateral margin, the second segment also partly chitinized, brownish." (Matthysse, 1944:439.)

#### ***Bovicola caprae* (Gurlt).**

*Trichodectes caprae* Gurlt, 1842:3, pl. 1, fig. 2.

*Trichodectes climax* Nitzsch, 1818:296.

*Bovicola caprae* (Gurlt) Ewing, 1929:123. Genotype.

The biting goat louse.

Oahu, and probably all of the main islands.

Immigrant. Cosmopolitan. I have seen specimens collected in Honolulu in 1920, and these were recorded by me in 1943 (1944:200).

Host: goat.

#### ***Bovicola equi* (Linnaeus).**

*Pediculus Equi* Linnaeus, 1758:612.

*Trichodectes equi* (Linnaeus), of authors.

*Bovicola equi* (Linnaeus) Ewing, 1929:123.

The biting horse louse.

Oahu (and the other main islands?).

Immigrant. Cosmopolitan. Not heretofore recorded from Hawaii, but reported to me as being present on army horses at Schofield Barracks in 1943.

Host: horse.

Control: local infestations may be controlled by sodium fluoride dusts, but if infestations are heavy and extensive the following standard dip solution has been recommended: white arsenic, 4 pounds; sal soda, 12 pounds; pine tar, 2 quarts; water, 250 gallons. The recently developed DDT dusts and sprays will probably replace the older control methods.

**Bovicola ovis** (Linnaeus).

*Pediculus Ovis* Linnaeus, 1758:611.

*Trichodectes ovis* (Linnaeus), of authors.

*Bovicola ovis* (Linnaeus) Ewing, 1929:123.

The biting sheep louse.

This cosmopolitan species has not been reported in literature from Hawaii, but circumstantial evidence leads me to believe that it will be found, especially on the island of Hawaii, if searched for. In some mainland localities when active dipping for sheep scab is not carried on, it is said that these lice build up occasionally in troublesome numbers, but that the usual dipping of the flocks keeps the louse under control.

**Genus FELICOLA** Ewing, 1929:122, 192

This genus can be recognized among the other Trichodectidae most easily because of its anteriorly pointed head.

**Felicola subrostrata** (Nitzsch).

*Trichodectes subrostrata* Nitzsch, 1818:296.

*Felicola subrostrata* (Nitzsch) Ewing, 1929:122. Genotype.

The biting cat louse.

Oahu, and probably on the other islands.

Immigrant. Cosmopolitan. This species was first recorded by me from specimens from Honolulu in 1943 (1944:200), but it has been here for a long while.

It is said that cats may become heavily infested with this louse, but no records of severe infestation in the Territory have come to my attention.

Control: sodium fluoride diluted in three or four parts of flour gives good control and will not irritate the cat's tender skin as will straight sodium fluoride.

**Family PHILOPTERIDAE** Burmeister, 1838**The Biting Bird Lice**

This is the largest family of lice. All our species can be distinguished easily from the only other family of lice of the Ischnocera found in Hawaii because of their two-segmented tarsi and five-segmented antennae. This family is in a state of taxonomic chaos. The following key is poor, but I am unable to improve it with the material and data at hand. It appears that some of these genera exist more in the minds of certain taxonomists than in nature.



## KEY TO THE GENERA OF PHILOPTERIDAE FOUND IN HAWAII

1. Inner margin of each eighth abdominal pleuron of female with a process bearing one or more spines; head not broader than long, each temple with only one very long seta and not produced into processes nor angulate in our species, which is found on the Hawaiian coot.....  
.....**Rallicola** Johnston and Harrison.  
Not such species ..... 2
- 2(1). Forehead without a complete marginal band, rarely rounded; clypeal suture and signature usually present.... 3  
Forehead rounded and surrounded by a narrow, unbroken marginal band; usually without a clypeal suture or signature ..... 12
- 3(2). Body elongate; trabecula small or absent..... 4  
Body rotund; trabecula usually large and movable..... 7
- 4(3). First three antennal segments of male distinctly elongated, especially second segment, and different from those of female; our species on albatrosses.....  
.....**Docophoroides** Giglioli.  
Not such species; antennae alike in the sexes..... 5
- 5(4). Clypeal region completely surrounded by a subcircular, hyaline margin; with a pair of small, peg-like, dorsal spines behind clypeal suture.....**Anotoecus** Cummings.  
Not such forms ..... 6
- 6(5). Male genitalia with basal plate uniformly sclerotized; parameres short .....**Philopterus** Nitzsch.  
Male genitalia with only lateral margins of basal plate sclerotized; parameres long, heavy, saber-shaped.....  
.....**Saemundsson** Timmerman.
- 7(3). Antennae similar in the sexes..... 8  
First antennal segment of male larger and different from that of female, first and third segments may have appendages ..... 9
- 8(7). Signature and clypeal suture absent; antennal bands interrupted medianly .....**Brüelia** Kéler.  
Signature and clypeal suture present.....  
.....**Quadriceps** Clay and Meinertzhagen.
- 9(7). Large species, 8 to 9 mm. long; signature broader than long; first antennal segment of male with an appendage .....**Harrisoniella** Bedford.  
Much smaller, 2 to 4 mm. long; signature not transverse; first segment of male antenna usually without an appendage ..... 10
- 10(9). Clypeus armed with two pairs of small, stout spines, these lying near apex, anterior pair directed forward and slightly downward, posterior pair directed upward and slightly backward; on pigeons.....**Columbicola** Ewing.  
Clypeus without such spines in addition to usual fine setae; not characteristic of pigeons..... 11

- 11(10). Sclerotized band behind clypeal suture interrupted in middle where each half turns backward..... **Pectinopygus** Mjoeberg.  
Clypeus without such a band..... **Perineus** Harrison.
- 12(2). Temples rounded .....13  
Temples angulate .....16
- 13(12). Males with intertergital abdominal plates..... **Cuclogaster** Carriker.  
Males without such plates.....14
- 14(13). Head with frontal rim with thickenings (with "preantennal chitinated processes") ..... **Oxylipaurus** Mjoeberg.  
Frontal rim without such processes.....15
- 15(14). Head with clypeal suture and pale transverse band present ..... **Lagopoecus** Waterston.  
Head without clypeal suture or pale transverse band ..... **Lipeurus** Nitzsch.
- 16(12). **Goniodes** Nitzsch, **Goniocotes** Burmeister, **Chelopistes** Kéler.  
These "genera" are in a state of confusion in literature.

#### Genus **ANOTOECUS** Cummings, 1916

**Anotoecus dentatus** (Scopoli) (fig. 144).

*Pediculus dentatus* Scopoli, Entomol. Carniol., p. 383, 1763 (I have not seen this reference).

*Philoaterus* (*Docophorus*) *icterodes* Nitzsch, 1818:290 (920, by error in original work).

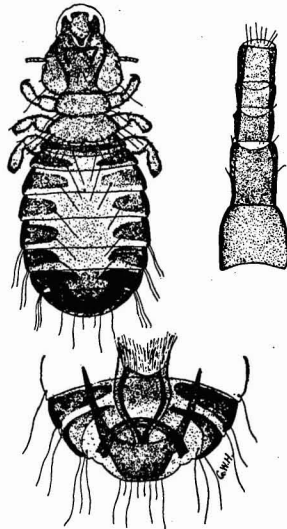


Figure 144—*Anotoecus dentatus* (Scopoli): female, female antenna and apex of male abdomen. (After Herrick, 1915.)

Kellogg, 1896:96, pl. 4, fig. 1.

*Philopterus dentatus* (Scopoli), of authors.

The red duck louse.

This species has not been recorded from Hawaii, but because it is a common, widespread louse of ducks, both wild and domesticated, I presume that it will be found in the islands if searched for. "This species is easily recognizable by its conspicuously rounding, uncolored clypeus with colored signature, and on each side of it the triangularly-headed anterior projection of the antennal band." (Kellogg, 1896:96-97.)

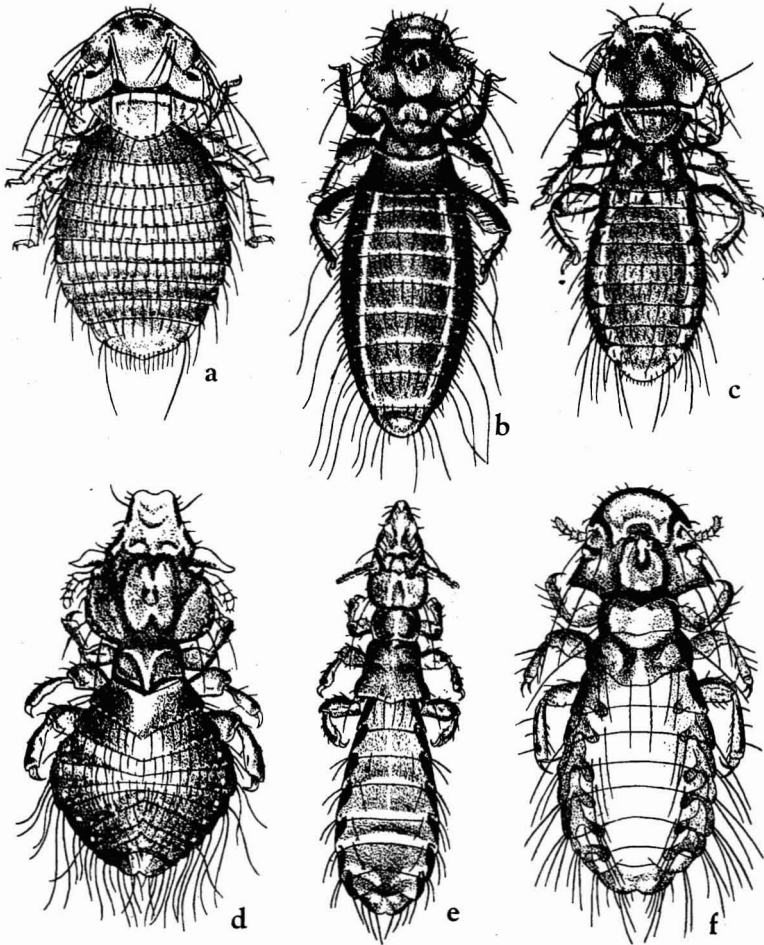


Figure 145—Some Hawaiian bird lice: a, *Colpocephalum hilensis* (Kellogg and Chapman), male; b, *Actornithophilus epiphanes* (Kellogg and Chapman), female; c, *Actornithophilus kilauensis* (Kellogg and Chapman), female; d, *Philopterus macgregori* (Kellogg and Chapman), female; e, *Brüelia stenozona* (Kellogg and Chapman), female; f, *Goniocotes chinensis* Kellogg and Chapman, female. (Rearranged from Kellogg and Chapman, 1904.)

Genus **DOCOPHOROIDES** Giglioli, 1864**Docophoroides brevis** (Dufour).

*Philoaterus Brevis* Dufour, 1835:674, pl. 31, fig. 3.

*Lipeurus taurus* Nitzsch, 1866:385.

*Eurymetopus taurus* (Nitzsch) Taschenberg, Kellogg and Paine, 1910:125.

Kellogg, 1908:51, pl. 2, fig. 16.

Laysan.

Indigenous. Cosmopolitan. First recorded from the Territory from Laysan by Kellogg and Paine in 1910.

Hosts: *Diomedea nigripes* (black-footed albatross), *Diomedea* (*Thalassarche*) *immutabilis* (Laysan albatross).

Genus **SAEMUNDSSONIA** Timmerman, 1936:100**Saemundssonina conicus** (Denny).

*Docophorus conicus* Denny, 1842:90, pl. 5, fig. 2.

*Docophorus fuliginosus* Kellogg, 1896:80, pl. 3, fig. 2.

*Docophorus fuliginosus* variety *hawaiiensis* Kellogg and Chapman, 1902:157; 1904:307 (type series from Kahului, Maui, and Hilo, Hawaii).

*Docophorus wallacei* Johnston and Harrison, 1912:369, figs. 5, 6.

*Philoaterus conicus* (Denny) Harrison, 1916:92.

Maui, Hawaii.

Indigenous. A widespread species. First recorded from Hawaii by Kellogg and Chapman in 1902.

Hosts: *Pluvialis* (*Charadrius*) *dominicus fulvus* (plover), *Heterocelus* (*Heteractitis*) *incanus* (wandering tattler).

**Saemundssonina snyderi** (Kellogg and Paine) (fig. 146, a-d).

*Docophorus snyderi* Kellogg and Paine, 1910:124, figs. 1, 2.

*Philoaterus snyderi* (Kellogg and Paine) Harrison, 1916:104. Ferris, 1932:71, fig. 20, a-d.

*Saemundssonina snyderi* (Kellogg and Paine) Thompson, 1939:74.

Laysan (type locality).

Indigenous. Also known from the Marquesas Islands.

Hosts: *Sterna lunata* (gray-backed tern) in Hawaii, *Sterna fuscata* (sooty tern) in the Marquesas.

Ferris (1932:71) says that this species may be the same as the Galapagan *Saemundssonina* (*Philoaterus*) *melanocephala* (Nitzsch).

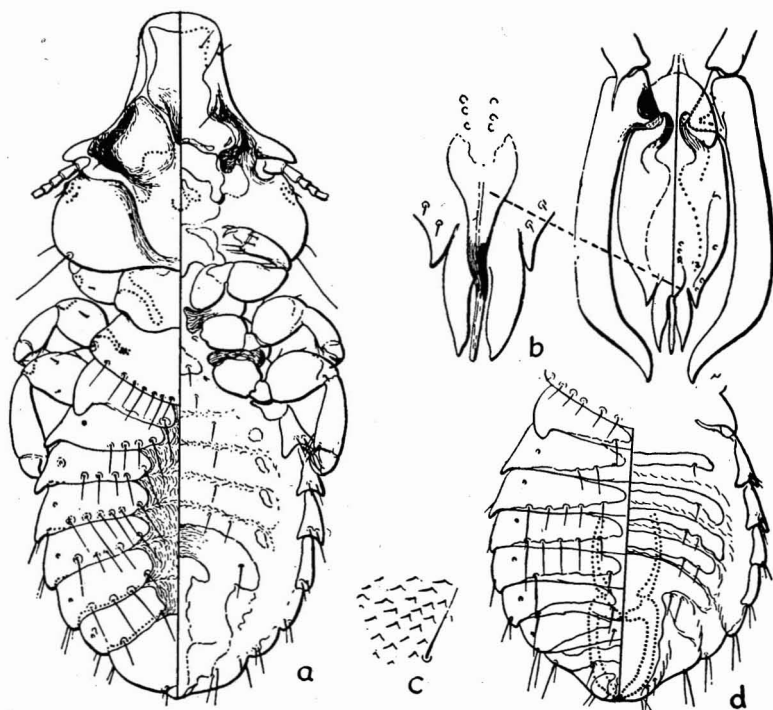


Figure 146—*Saemundssonina snyderi* (Kellogg and Paine): a, female; b, male genitalia; c, ornamentation of derm of venter of female; d, male abdomen, drawn to larger scale than female. (After Ferris, 1932:71.)

### Genus **PHILOPTERUS** Nitzsch, 1818

*Docophorus* Nitzsch, 1818.

**Philopterus macgregori** (Kellogg and Chapman) (fig. 145, d).

*Docophorus macgregori* Kellogg and Chapman, 1902:156, pl. 13, fig. 1; 1904:306, pl. 10, fig. 1.

Endemic(?). Maui (type series from Kahului and Iao Valley).

Host: *Chlorodrepanis virens* ("amakihi").

**Philopterus subflavescens** (Geoffroy).

*Pediculus subflavescens* Geoffroy, 1762:599.

*Docophorus communis* Nitzsch, 1838:425.

*Philopterus subflavescens* (Geoffroy) Harrison, 1916:105.

Maui, Hawaii.

Immigrant. First recorded from Hawaii by Kellogg and Chapman in 1902. Known also from the Galapagos Islands.

Hosts in Hawaii: *Carpodacus mexicanus obscurus* (linnet); *Munia nisoria* (Chinese sparrow).

Genus **RALLICOLA** Johnston and Harrison, 1911

**Rallicola advena** (Kellogg).

*Oncophorus advena* Kellogg, 1896:133, pl. 11, figs. 1, 2. Kellogg and Chapman, 1902:160; 1904:311.

*Rallicola advena* (Kellogg) Harrison, 1916:126.

Maui, Hawaii.

Indigenous. Also found in California, where it was described from the American coot.

Hosts: *Fulica americana alai* (Hawaiian coot), *Vestiaria coccinea* ("iiwi"),

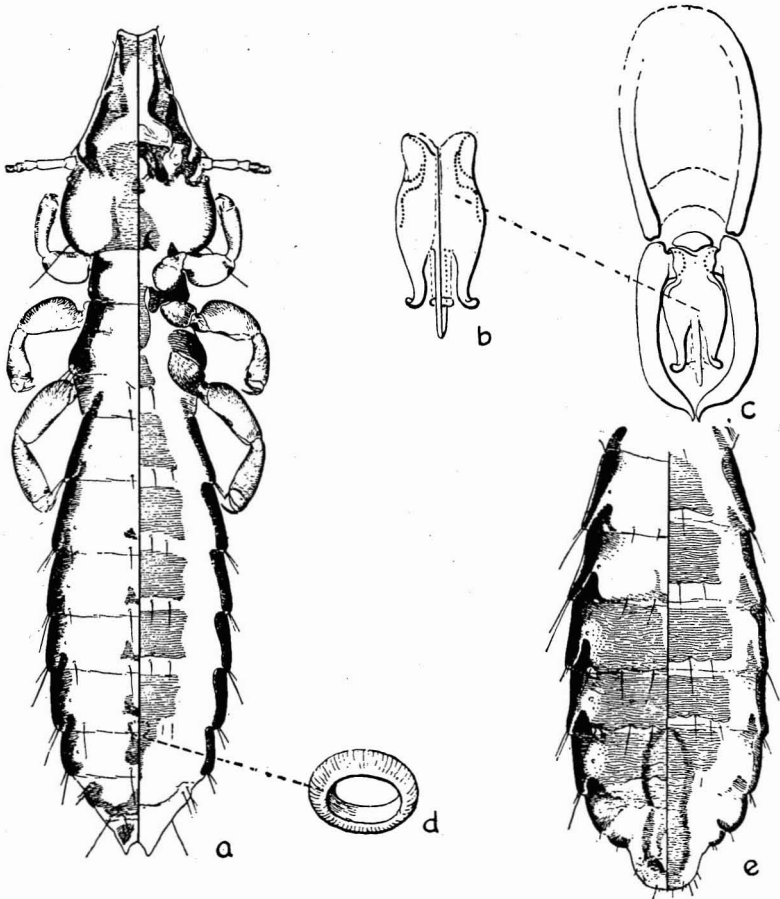


Figure 147—*Quadriceps birostris* (Giebel): a, female; b, endomeral complex of male genitalia; c, male genitalia; d, spermatheca of female; e, abdomen of male, drawn to larger scale than female. (After Ferris, 1932:68.)

*Heterocelus* (*Heteractitis*) *incanus* (wandering tattler). These two latter records appear to be erroneous. Thompson (1939:122) believes that the coot is the true host.

### Genus **QUADRACEPS** Clay and Meinertzhagen

#### **Quadraceps birostris** (Giebel) (fig. 147, a-e).

*Nirmus birostris* Giebel, 1874:174.

*Nirmus gloriosus* Kellogg and Kuwana, 1902:467, pl. 29, fig. 1, in part.

*Degeeriella gloriosa* (Kellogg and Kuwana) Harrison, 1916:114. Ferris, 1932: 68, fig. 18, a-e.

*Degeeriella birostris* (Giebel) Bedford, 1936:88.

Laysan.

Indigenous. Widespread. First recorded from Hawaii by Kellogg and Paine in 1910.

Host: *Sterna lunata* (gray-backed tern).

#### **Quadraceps oraria** (Kellogg).

*Nirmus orarius* Kellogg, 1896:104, pl. 5, fig. 104.

*Nirmus orarius hawaiiensis* Kellogg and Chapman, 1902:159; 1904:310 (type from Kahului, Maui).

*Degeeriella oraria* (Kellogg) Johnston and Harrison, 1912:368.

Maui.

Indigenous. Widespread. First recorded from the islands in 1902 by Kellogg and Chapman.

Hosts: *Pluvialis* (*Charadrius*) *dominicus fulvus* (plover), *Fulica americana alai* (Hawaiian coot). Thompson (1939:120) says that the plover is the true host.

#### **Quadraceps separata** (Kellogg and Kuwana) (fig. 148, a-e).

*Nirmus separatus* Kellogg and Kuwana, 1902:472, pl. 29, fig. 6.

*Nirmus gloriosus* Kellogg and Kuwana, 1902:467, pl. 29, fig. 1, in part, through misidentification.

*Nirmus gloriosus* variety *emarginatus* Kellogg and Chapman, 1902:159 (type from Kahului, Maui); 1904:310.

*Degeeriella separata* (Kellogg and Kuwana) Harrison, 1916:123. Ferris, 1932: 69, fig. 19, a-e.

Maui, Laysan.

Indigenous. Widespread. First recorded from the Territory by Kellogg and Chapman in 1902.

Host: *Anous stolidus pileatus* (noddy tern).

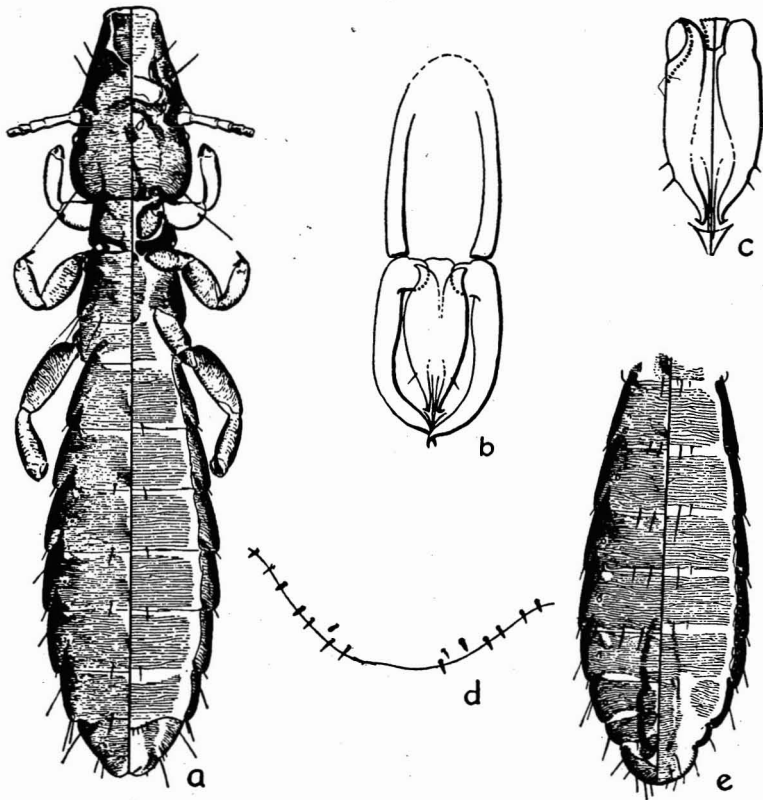


Figure 148—*Quadraceps separata* (Kellogg and Kuwana): a, female; b, male genitalia; c, endomeral complex of male genitalia; d, margin of vulva; e, abdomen of male, drawn to larger scale than female. (After Ferris, 1932:70.)

Genus **BRÜELIA** Kéler, 1936

**Brüelia stenozona** (Kellogg and Chapman) (fig. 145, e).

*Nirmus stenozonus* Kellogg and Chapman, 1902:158, pl. 13, fig. 3; 1904:308, pl. 10, fig. 3.

*Degeeriella stenozona* (Kellogg and Chapman), of authors.

Immigrant(?). Hawaii (type locality: Hilo).

Hosts: *Vestiaria coccinea* ("iiwi"), *Munia nisoria* (Chinese sparrow).

**Brüelia vulgata** (Kellogg).

*Nirmus vulgatus* Kellogg, 1896:496, pl. 47, fig. 5.

*Degeeriella vulgata* (Kellogg), of authors.

Oahu, Gardner Island.

Immigrant. Widespread.

Host: *Passer domesticus* (English sparrow).



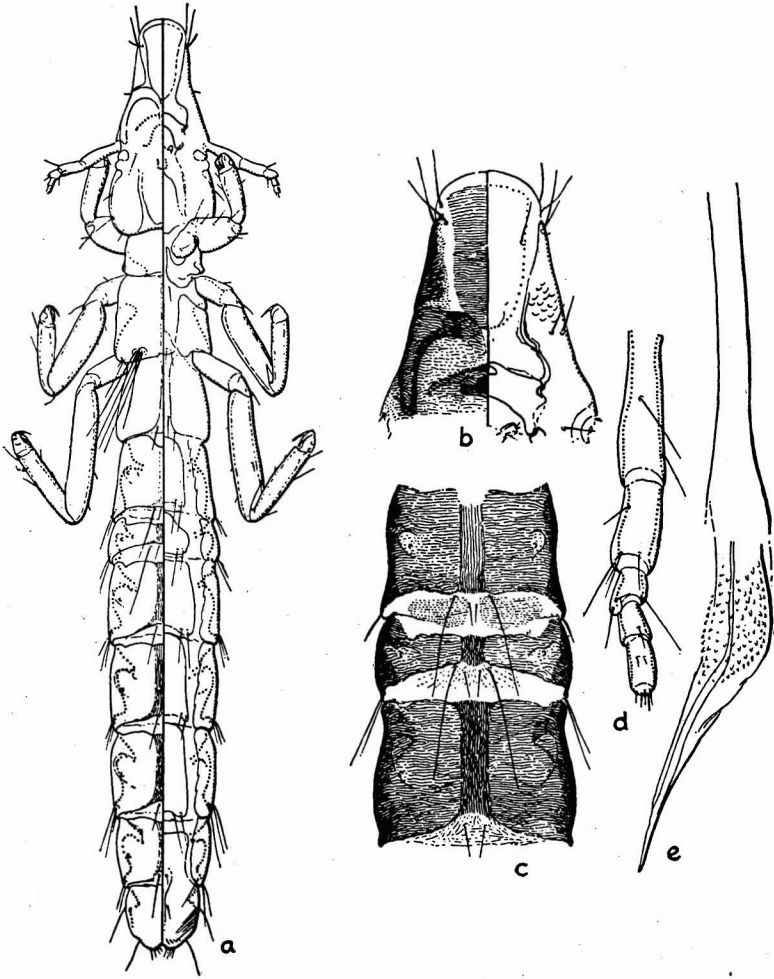


Figure 149—*Pectinopygus* (*Epifregata*) *gracilicornis* (Piaget): a, male; b, anterior part of head; c, flexing segment of abdomen; d, antenna of male; e, male genitalia. (After Ferris, 1932:61.)

Genus **PECTINOPYGUS** Mjoeberg, 1910

Thompson (1937:539) redefined this genus.

**Pectinopygus** (*Epifregata*) *gracilicornis* (Piaget) (fig. 149, a-e).

*Lipeurus gracilicornis* Piaget, 1880:309, pl. 25, fig. 6.

*Esthiopterum gracilicornis* (Piaget) Ferris, 1932:61, fig. 13, a-e.

*Pectinopygus* (*Epifregata*) *gracilicornis* (Piaget) Thompson, 1937:542.

Laysan, Necker.

Indigenous. First recorded from the leeward Hawaiian islands by Kellogg and Paine in 1910. Widespread.

Hosts: *Fregata minor palmerstoni* (aquila) (frigate bird), *Sterna lunata* (gray-backed tern).

**Pectinopygus (Pectinopygus) sulae** (Rudow) (fig. 150, a-b).

*Lipeurus sulae* Rudow, 1870:134.

*Lipeurus gracilicornis* variety *major* Kellogg, 1899:30, pl. 3, fig. 6.

*Lipeurus potens* Kellogg and Kuwana, 1902:477, pl. 30, fig. 1.

*Pectinopygus* (*Pectinopygus*) *sulae* (Rudow) Waterston, 1923:289. Ferris, 1932:64, figs. 16, a, b; 17, a-d.

See Thompson, 1939:211, for detailed synonymy.

Laysan, Necker.

Indigenous. First recorded from Laysan by Kellogg and Paine in 1910. Widespread.

Hosts: *Fregata minor palmerstoni* (aquila) (frigate bird), *Sterna lunata* (gray-backed tern), *Sula sula rubripes* (piscator) (red-footed booby).

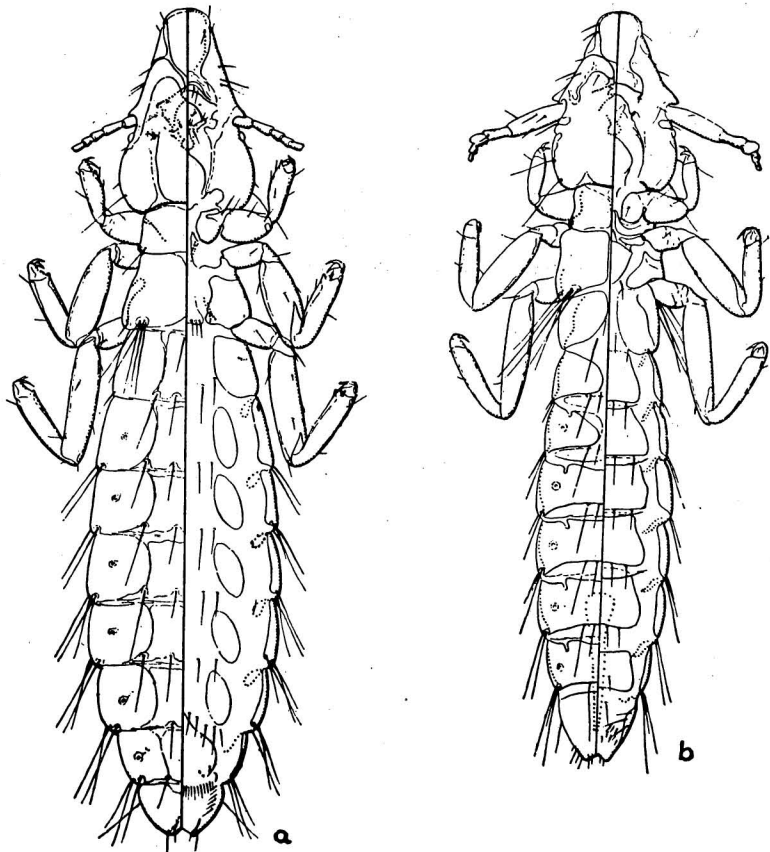


Figure 150—*Pectinopygus sulae* (Rudow): a, female; b, male. (After Ferris, 1932:65.)

Genus **HARRISONIELLA** Bedford, 1929**Harrisoniella ferox** (Giebel).

*Lipeurus ferox* Giebel, 1867:196.

*Lipeurus densus* Kellogg, 1896:114, pl. 7, figs. 1, 2.

*Esthiopterum diomediae* (Fabricius) Harrison, 1916:133.

*Harrisoniella diomediae* (Fabricius) Bedford, 1929:529.

*Harrisoniella ferox* (Giebel) Clay, 1940:298; see also pp. 299–302 for discussion of synonymy. Fabricius' species *diomediae* is a *Perineus* and distinct from this form.

Laysan.

Indigenous. Widespread. First recorded from the Territory by Kellogg and Paine in 1910.

Hosts: *Diomedea nigripes* (black-footed albatross), *Diomedea* (*Thalassarche*) *immutabilis* (Laysan albatross).

Cope (1940:117–142, figs. 54–66) gives a detailed account of the morphology of this species.

Genus **PERINEUS** Harrison, in Thompson, 1936:41**Perineus concinnus** (Kellogg and Chapman).

*Lipeurus concinnus* Kellogg and Chapman, 1899:97, pl. 7, fig. 2.

*Perineus concinnus* (Kellogg and Chapman) Harrison, 1937:29.

Laysan.

Indigenous. Described from California. First recorded from the Territory by Kellogg and Paine in 1910.

Host: *Diomedea* (*Thalassarche*) *immutabilis* (Laysan albatross).

**Perineus giganticulum** (Kellogg).

*Nirmus giganticulus* Kellogg, 1896:105, pl. 5, fig. 6.

*Lipeurus confidens* Kellogg, 1899:26, pl. 3, fig. 1.

*Lipeurus miriceps* Kellogg and Kuwana, 1902:480, pl. 30, fig. 4.

*Perineus confidens* (Kellogg) Thompson, 1936:42.

Laysan.

Indigenous. Widespread. First reported from the Territory in 1910 by Kellogg and Paine.

Hosts: *Diomedea nigripes* (black-footed albatross), *Sterna lunata* (gray-backed tern).

Genus **COLUMBICOLA** Ewing, 1929:116

Ewing separated this group of long, slender lice from *Esthiopteryx* because the clypeus has on its dorsal surface two pairs of stout spines, one pair directed forward, the other pair directed upward and backward. The first antennal segment is enlarged in the male, is much larger than that of the female, and the third segment has its apex produced into a thumb-like process. The antennae of the female barely attain the hind margin of the head, whereas those of the male distinctly surpass it in length.

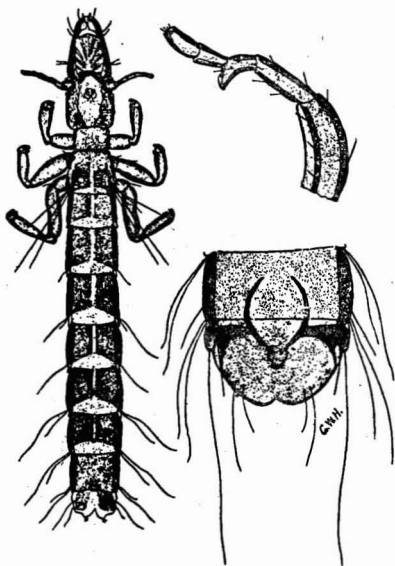


Figure 151—*Columbicola columbae* (Linnaeus), the pigeon louse: female, male antenna and apex of male abdomen. (After Herrick, 1915.)

***Columbicola columbae*** (Linnaeus) (fig. 151).

*Pediculus Columbae* Linnaeus, 1758:614.

*Lipeurus bacillus* Nitzsch, 1874:215 (*baculus*, p. 216), pl. 16, figs. 8-9; pl. 20, fig. 3.

*Columbicola columbae* (Linnaeus) Ewing, 1929:117, fig. 66.

The pigeon louse.

Kauai, Oahu, Maui, Hawaii.

Immigrant. Widespread. First recorded in the Territory by me in 1944 from specimens collected in Honolulu in 1943.

Hosts: *Columba livia* (pigeon), *Geopelia striata striata* (barred-shoulder dove), *Streptopelia (Turtur) chinensis* (Chinese dove).

This is a common species on pigeons, and it may be found most abundantly on the flight feathers of the birds. Sodium fluoride dust will control it.

Martin (1934:6-16) has written an account of the biology of this louse. She found that the lice were dispersed, in part, by attaching themselves to the pigeon louse fly (*Pseudolynchia* [Hippoboscidae]). She reports that the lice feed almost exclusively on feather barbules, that the egg stage is about 4 days, and that the three nymphal instars have a duration of about 6.75 days. She gives illustrations of the eggs, three larval instars and the adult.

In 1938 I collected this species from a native fruit pigeon shot in the jungle of Viti Levu, Fiji.

Genus **LIPEURUS** Nitzsch, 1818

***Lipeurus caponis*** (Linnaeus) (fig. 152, a-f).

*Pediculus Caponis* Linnaeus, 1758:614.

The variable chicken louse.

Kauai, Oahu, Hawaii and probably the other islands.

Immigrant. Cosmopolitan. First recorded from the Territory by Illingworth in 1928 from specimens found in Honolulu in 1926.

Hosts: chicken, *Phasianus colchicus torquatus* (Chinese pheasant).

Control: sodium fluoride dust gives good control.

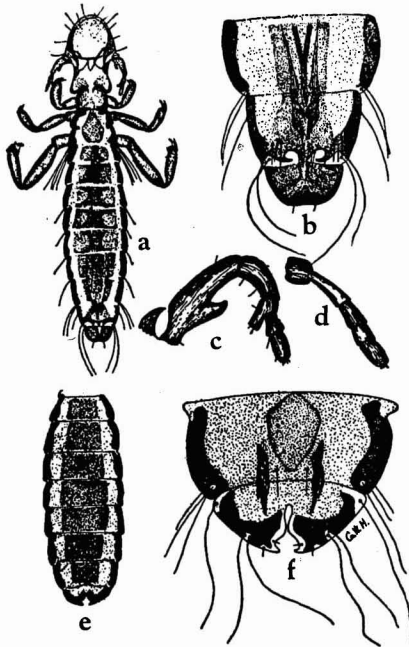


Figure 152—*Lipeurus caponis* (Linnaeus), the variable chicken louse: a, male; b, posterior end of female abdomen; c, male antenna; d, female antenna; e, female abdomen; f, two terminal abdominal segments of female. (After Herrick, 1915.)

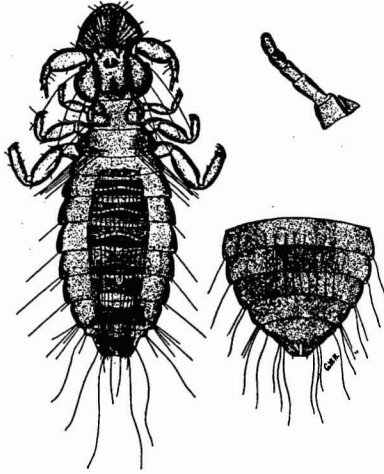


Figure 153—*Cuculotogaster heterographus* (Nitzsch): male, female antenna and end of female abdomen. (After Herrick, 1915.)

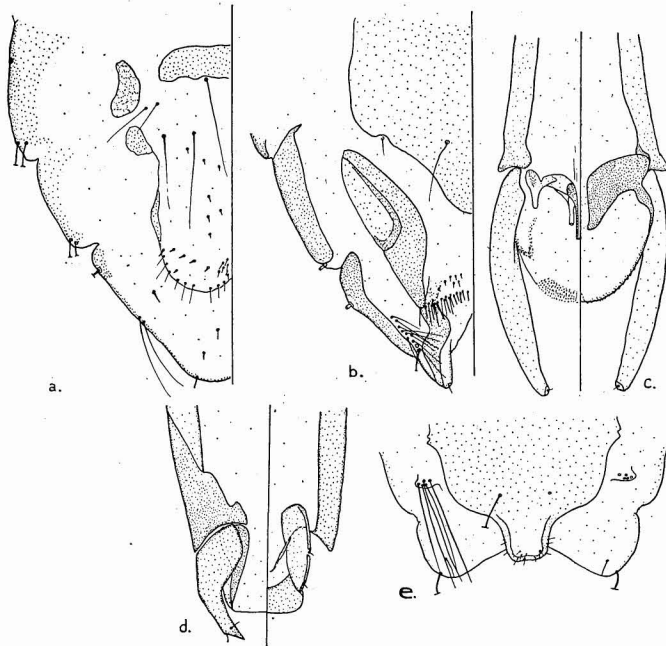


Figure 154—Details of the genitalia of some Mallophaga: a, *Cuculotogaster heterographus* (Nitzsch), posterior segments of female abdomen; b, the same of *Oxylipeurus polytrapezius* (Burmeister); c, genitalia of female of same species; d, *Lagopoecus docophoroides* (Piaget), male genitalia; e, *Oxylipeurus polytrapezius* (Burmeister), posterior abdominal segments of male. (Original drawings loaned by Miss Theresa Clay.)

Genus **CUCLOTOGASTER** Carriker, 1936

*Gallipeurus* Clay, 1938:135.

**Cucлотogaster heterographus** (Nitzsch) (figs. 153; 154, a).

*Lipeurus heterographus* Nitzsch, 1866:381.

*Gallipeurus heterographus* (Nitzsch) Clay, 1938:136, figs. 15, 16, 17, 18a.

Oahu and probably the other main islands.

Immigrant. Widespread. First recorded from the Territory in 1928 by Illingworth from specimens collected in Honolulu in 1926.

Host: chicken.

The usual control by the use of sodium fluoride is effective.

Genus **OXYLIPEURUS** Mjoeberg, 1910

**Oxylipeurus polytrapezius** (Burmeister) (figs. 154, b, c, e; 155).

*Lipeurus polytrapezius* Burmeister, 1838:434.

(*Pediculus galli-pavonis* Geoffroy, 1762:600, new edition, 1799:600, name used in our literature. The true *galli-pavonis* belongs to *Goniodes*; see Clay, 1938: 181, pl. 12, fig. 4, text figs. 37a, c, 39b, for explanation.)

The turkey louse.

Oahu and probably other islands.

Immigrant. Widespread. First recorded from the Territory by Illingworth in 1928 from specimens collected in Honolulu in 1926.

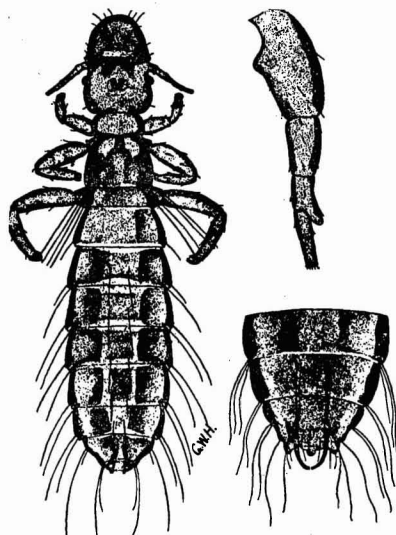


Figure 155—*Oxylipeurus polytrapezius* (Burmeister): female, male antenna and apex of male abdomen. (After Herrick, 1915.)

Host: turkey.

This species may become abundant on the flight feathers. Sodium fluoride dust is recommended for control.

Genus **LAGOPOECUS** Waterston, 1922

**Lagopoecus docophoroides** (Piaget) (fig. 154, d).

*Lipeurus docophoroides* Piaget, 1880:351, pl. 28, fig. 9.

*Lipeurus docophoroides* variety *minhaensis* Kellogg and Chapman, 1902:159; 1904:310. Described from Lahaina, Maui. First record for Hawaii.

*Lipeurus minhaensis* (Kellogg and Chapman) Thompson, 1939:16. Synonymy by Clay, 1938:195, fig. 43d.

Maui.

Immigrant. Described from California.

Host: Kellogg and Chapman gave the host as *Acridotheres tristis*, the mynah, but this must have been recorded from a straggler. The true host is evidently the quail. It was described from the California quail, *Lophortyx californica californica*. I have no further notes on this species.

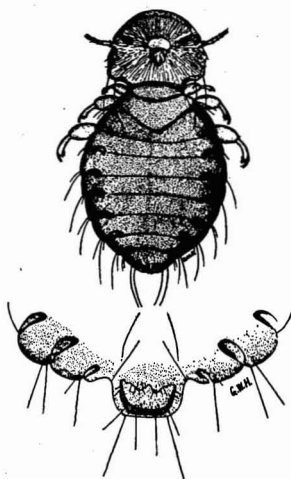


Figure 156—*Goniocotes hologaster* (Nitzsch), the fluff louse; male, above; enlarged sketch of apex of female abdomen, below. (After Herrick, 1915.)

Genus **GONIOCOTES** Burmeister, 1838

The members of this genus, together with those of *Goniodes*, have a characteristic, broad appearance. Most of the species are found on gallinaceous and columbine birds.



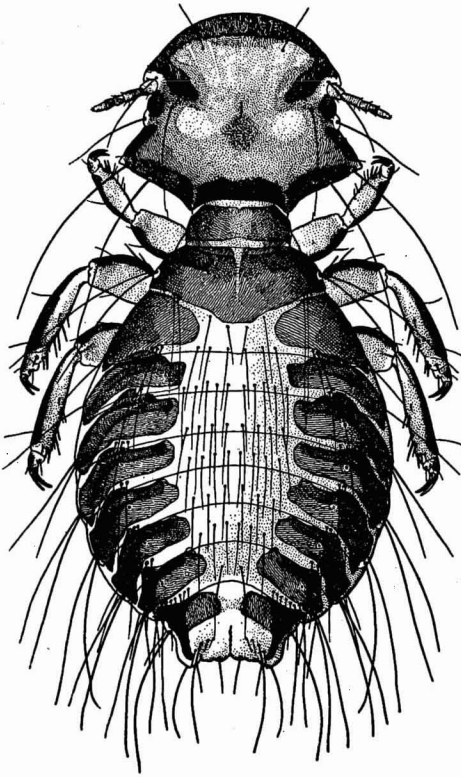


Figure 157—*Goniodes dissimilis* Denny, female. (After Clay, 1940; drawing by Terzi.)

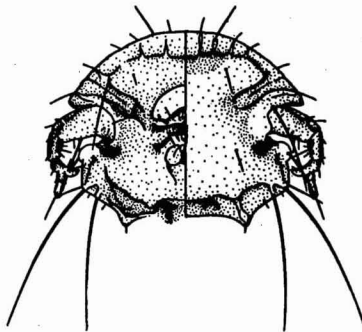


Figure 158—*Goniodes dissimilis* Denny, head of male. (After Clay, 1940.)

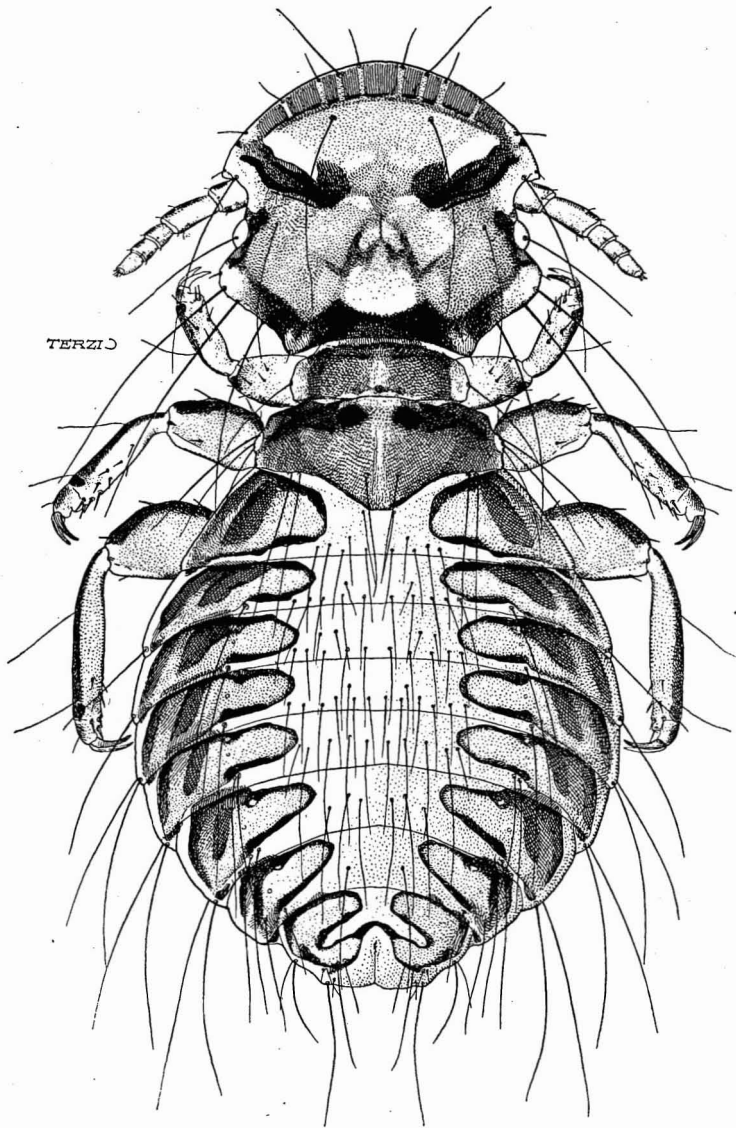


Figure 159—*Goniodes gigas* (Taschenberg), the large chicken louse, female. (After Clay, 1940.)

**Goniocotes chinensis** Kellogg and Chapman (fig. 145, f).

*Goniocotes chinensis* Kellogg and Chapman, 1902:160, pl. 13, fig. 5; 1904:311, pl. 10, fig. 5.

Kauai, Maui (type locality: Kahului), Hawaii.

Immigrant, but not recorded elsewhere.

Hosts: *Streptopelia (Turtur) chinensis* (Chinese dove), *Geopelia striata striata* (barred-shoulder dove).

**Goniocotes hologaster** Nitzsch (fig. 156).

*Goniocotes hologaster* Nitzsch, 1838:431.

The fluff louse.

Oahu, Hawaii and probably on the other islands.

Immigrant. First recorded from the Territory by Illingworth in 1928 from specimens collected in Honolulu in 1926.

Hosts: chicken, turkey, *Phasianus colchicus torquatus* (Chinese pheasant).

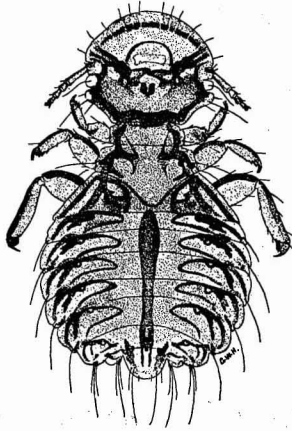


Figure 160—*Goniodes gigas* (Taschenberg) male. (After Herrick, 1915.)

#### Genus **GONIODES** Nitzsch, 1818

The members of this genus, like those of *Goniocotes*, are partial to gallinaceous birds.

In addition to the following four species, *Goniodes pavonis* (Linnaeus), on peafowl, may also be found in Hawaii, but it has not yet been recorded here.

**Goniodes dissimilis** Denny (figs. 157, 158).

*Goniodes dissimilis* Nitzsch, 1818:294.

*Goniodes dissimilis* Denny, 1842:57, 162, pl. 12, fig. 6. Clay, 1940:62, figs. 41-43.

## Oahu.

Immigrant. Widespread. Not recorded from the Territory heretofore, but I have specimens before me which were taken from a chicken in Nuuanu Valley in 1932 and kindly identified for me by Mr. G. B. Thompson.

The illustrations serve to distinguish this species easily from *G. gigas*, the other *Goniodes* occurring on chickens in Hawaii. The third antennal segment of the male of this species has a prominent process, whereas that of *gigas* has no process.

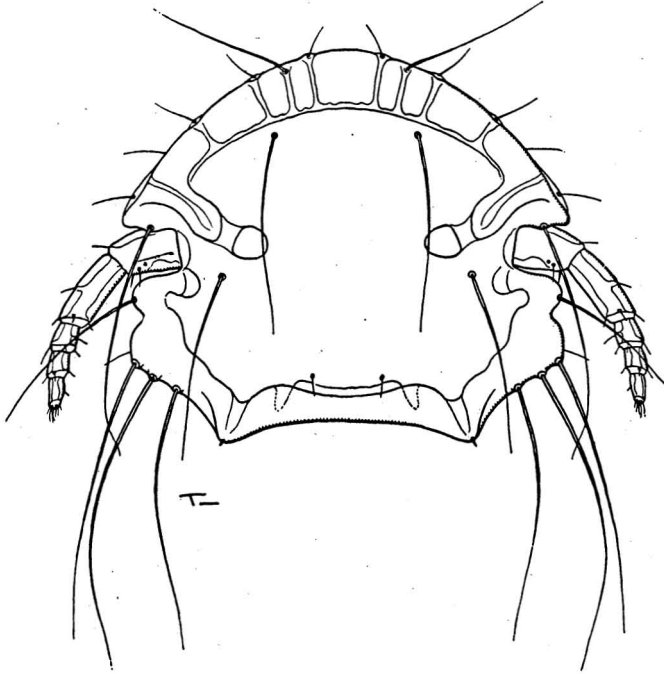


Figure 161—*Goniodes gigas* (Taschenberg), head of male. (After Clay, 1940.)

***Goniodes gigas*** (Taschenberg) (figs. 159, 160, 161).

*Goniocotes gigas* Taschenberg, 1879:104, pl. 1.

*Goniodes gigas* (Taschenberg) Clay, 1940:33, figs. 21–22.

The large chicken louse.

Kauai, Oahu, and probably on the other main islands.

Immigrant. Widespread. First recorded from Hawaii by Illingworth in 1928 from specimens collected at Waipio, Oahu, in 1926.

Hosts: guinea fowl, domestic chicken. Thompson (1938:188) and Clay (1940:33) say that the guinea fowl is the normal host.

**Goniodes lativentris** Uchida.

*Goniodes lativentris* Uchida, 1916:81, figs. 1, 2.

Oahu.

Immigrant. Described from Japan. First found in Hawaii in 1945 by a member of the armed forces, but not recorded in Hawaiian literature heretofore.

Host: "dove." (The dove the Hawaiian specimens were obtained from was either *Streptopelia chinensis* or *Geopelia striata*; I do not know which).

**Goniodes mammillatus** Rudow (fig. 162, a-c).

*Goniodes mammillatus* Rudow, 1870:483. Clay, 1940:60, fig. 40.

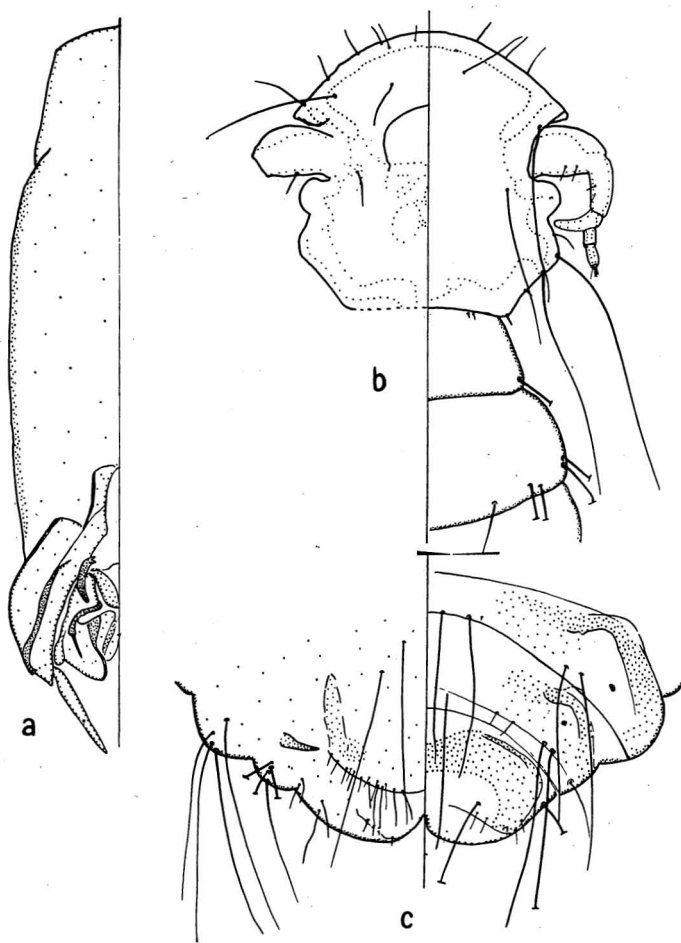


Figure 162—*Goniodes mammillatus* Rudow; a, male genitalia; b, head and thorax; c, apex of female abdomen. (Original drawings loaned by Miss Theresa Clay.)

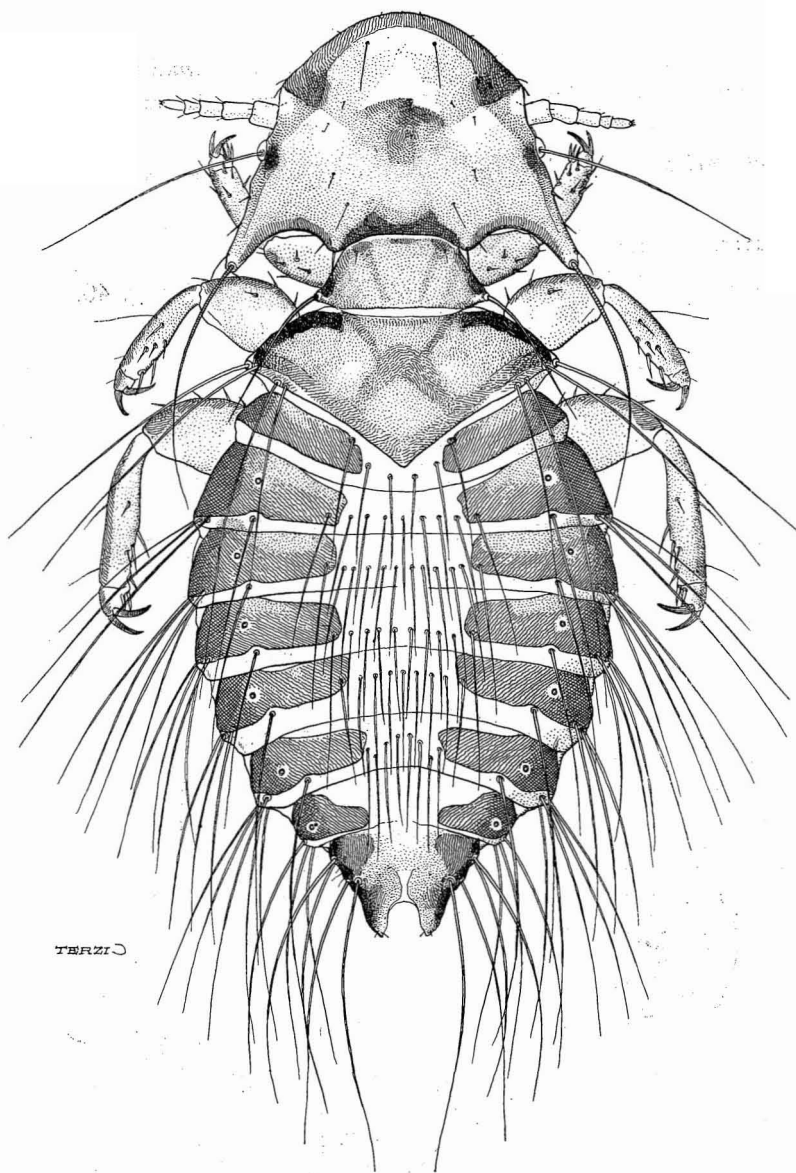


Figure 163—*Chelopistes meleagridis* (Linnaeus), the large turkey louse, female. (After Clay, 1941; cut loaned by Parasitology.)

Hawaii.

Immigrant. Widespread. First recorded from the Territory by me in 1943 (1944:200) from specimens collected by Paul Baldwin in Hawaii National Park in 1938. Described from Europe.

Host: *Lophortyx californica vallicola* (California valley quail). Essig (1929) records it from grouse and ptarmigans in western North America. I have seen an example from a pheasant from Hawaii.

Genus **CHELOPISTES** Kéler, 1939:180

*Virgula* Clay, 1941:119.

**Chelopistes meleagridis** (Linnaeus) (figs. 163; 164; 165, a-b; 166, a-c).

*Pediculus Meleagridis* Linnaeus, 1758:613.

*Goniodes stylifer* Nitzsch, 1838:432. Genotype of *Chelopistes*.

*Virgula meleagridis* (Linnaeus) Clay, 1941:119, figs. 1-4.

The large turkey louse.

Oahu, Molokai.

Immigrant. Widespread; described from Europe. First recorded from the Territory by Van Dine in 1909 from material collected on Molokai.

Hosts: turkey, chicken.

This common louse of turkeys will yield to control by sodium fluoride dust.

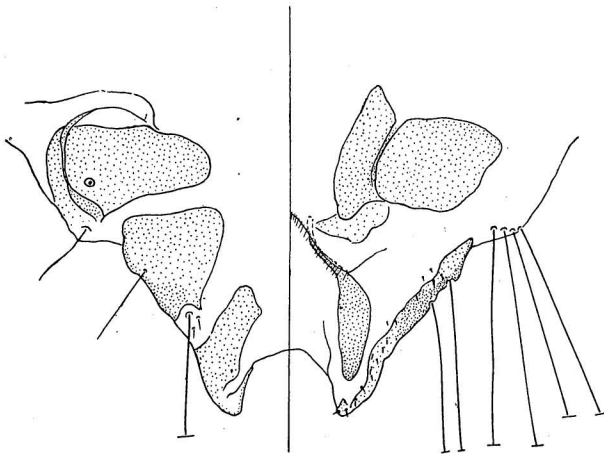


Figure 164—*Chelopistes meleagridis* (Linnaeus), terminal abdominal segments of female. (After Clay, 1941; cut loaned by *Parasitology*.)

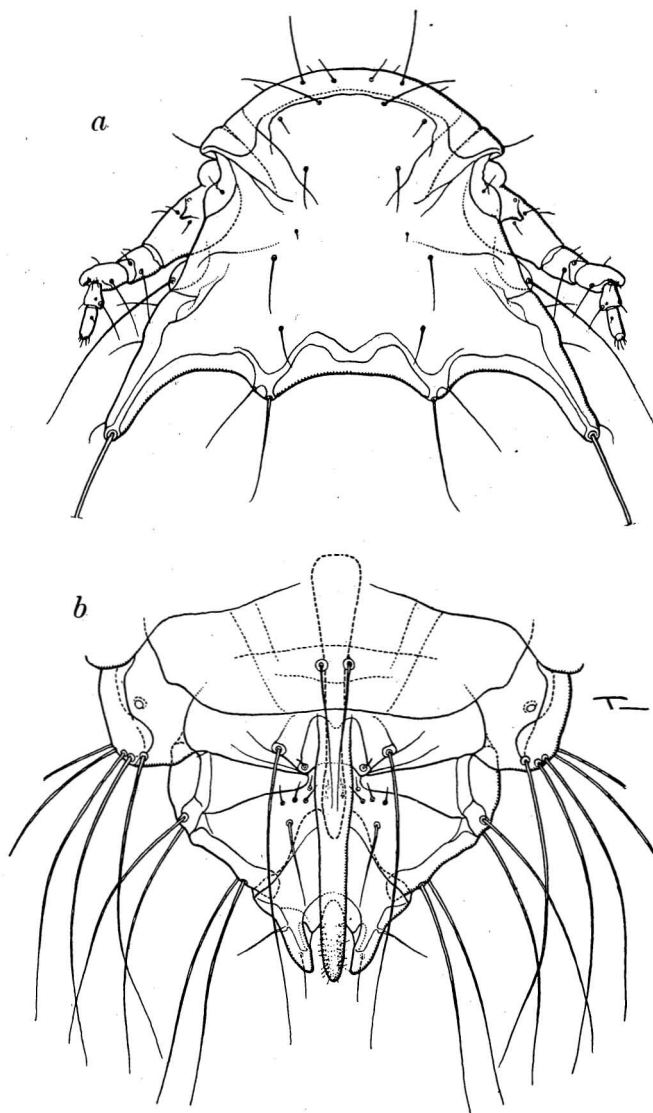


Figure 165—*Chelopistes meleagridis* (Linnaeus), male: a, head; b, terminal abdominal segments. (After Clay, 1941; cut loaned by *Parasitology*.)



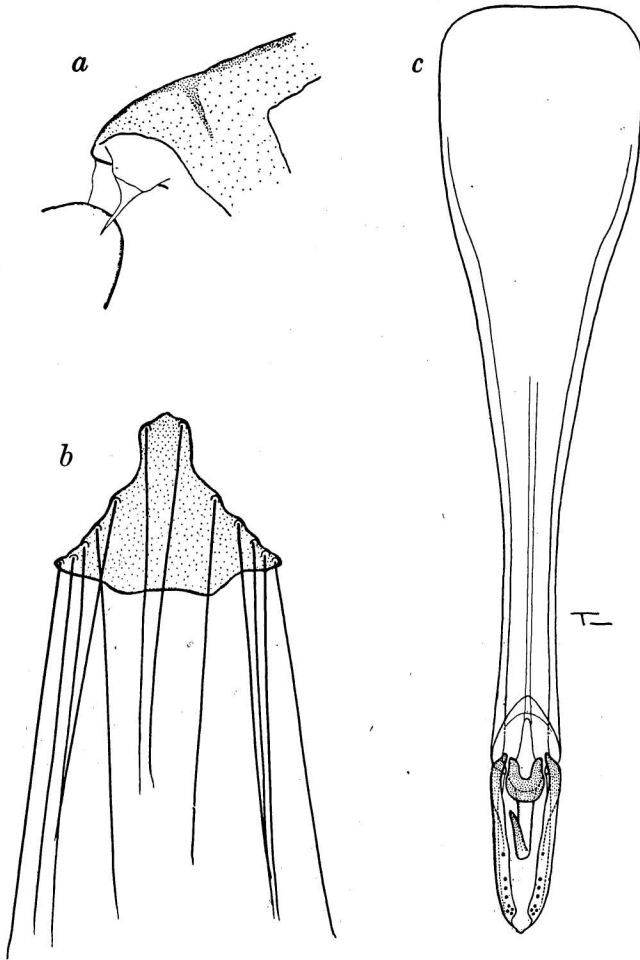


Figure 166—*Chelopistes meleagridis* (Linnaeus), details of male: a, clavi; b, sternal thoracic plate; c, genitalia. (After Clay, 1941; cut loaned by *Parasitology*.)

#### SPECIES INCERTAE SEDIS

The following two species appear not to belong to the genera to which they have been assigned. The types must be examined before they can be placed in systematic order.

***Degeeriella* (?) *diaprepes*** (Kellogg and Chapman) (fig. 167).

*Nirmus diaprepes* Kellogg and Chapman, 1902:158, pl. 13, fig. 4; 1904:309, pl. 10, fig. 4.

*Degeeriella diaprepes* (Kellogg and Chapman) Thompson, 1939:75.

Endemic(?). Hawaii (type locality: Hilo).

Host: *Vestiaria coccinea* ("iiwi").

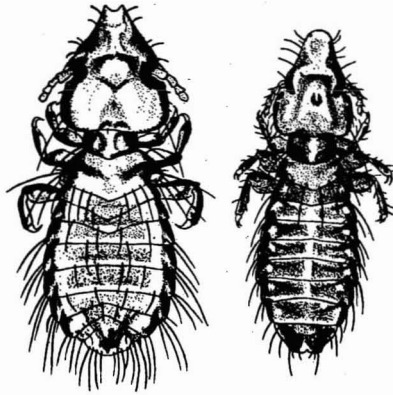


Figure 167—*Degeeriella* (?) *diaprepes* (Kellogg and Chapman), male, left; *Degeeriella* (?) *minhaensis* (Kellogg and Chapman), female, right. (Rearranged from Kellogg and Chapman, 1904.)

***Degeeriella* (?) *minhaensis* (Kellogg and Chapman) (fig. 167).**

*Nirmus minhaensis* Kellogg and Chapman, 1902:157, pl. 13, fig. 2; 1904:307, pl. 10, fig. 2.

*Degeeriella minhaensis* (Kellogg and Chapman) Thompson, 1939:120.

Maui (type locality: Lahaina).

Immigrant; status uncertain.

Host: *Acridotheres tristis* (mynah).

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While this volume was in proof, "Mallophaga Collected by the Tanager Expedition" by G. B. Thompson (1948) has come to hand. It includes several species new to Hawaii, as follows:

*Austromenopon* (?) *infrequens* (Kellogg, 1896), Pearl and Hermes Reef, on *Laurus hyperboreus*. *Austromenopon* *steriophilum* (Ferris, 1932), Laysan, on *Anous stolidus pileatus*. *Actornithophilus milleri* (Kellogg and Kuwana, 1902), Laysan, on *Anous stolidus pileatus*. *Longimenopon puffinus* Thompson (a new genus and species), Laysan, on *Puffinus pacificus cuneatus* and *Puffinus nativitatis*. *Saemundssonina* (?) *gonothorax* (Giebel, 1871), Pearl and Hermes Reef, on *Laurus hyperboreus*. *Luniceps* species (?), Laysan, on *Numenius tahitiensis*. *Halipeurus mirabilis* Thompson, 1940, Laysan, on *Puffinus pacificus cuneatus* and *Diomedea nigripes*. *Harrisoniella* species (?), Laysan and Ocean Islands, on *Diomedea immutabilis* and *Diomedea nigripes*. *Giebelia* (?) *mirabilis* Kellogg, 1896, Laysan, on *Puffinus pacificus cuneatus*. *Docophoroides* species (?), Laysan, on *Diomedea immutabilis*.

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The bibliography for this section is combined with that of the Anoplura and appears at the end of the section on Anoplura (p. 315).

## Order ANOPLURA Leach, 1815

(*anoplus*, unarmed; *oura*, tail)

### Sucking Lice

*Aptera* Linnaeus, 1758, in part.

*Parasita* Latreille, 1802, in part.

*Anoplura* Leach, 1815.

*Siphunculata* Latreille, 1825.

*Pediculina* Burmeister, 1835.

*Pediculida* Mayer, 1876.

*Polyptera* Banks, 1892.

*Pediculoidea* Crampton, 1921.

*Hemiptera*, suborder *Parasita*, Comstock and Comstock, 1895.

*Hemiptera*, suborder *Parasitica*, Osborn, 1923.

*Psocoida* Weber, 1939, in part.

According to the law of priority, the correct name for this order appears to be *Parasita* Latreille, as has been recently pointed out by Essig (1942:202). However, the term *Anoplura* has been in use for so long that perhaps more confusion than uniformity would result from the usage of *Parasita* in place of *Anoplura*. The term *Anoplura* should probably be stabilized through the provision made by the International Rules for Zoological Nomenclature for *nomina conservanda*.

Body elongate, depressed, soft, but integument tough. Head prognathous, exposed mouth parts retractile, highly modified for piercing skin and sucking blood, haustellum present, mandibles obsolete, palpi absent, maxillae and labium greatly modified into dorsal and ventral piercing stylets, labrum inverted as the roof of the fore part of the buccal cavity, hypopharynx tube-like, enclosing the salivary duct; antennae short, exposed, filiform, three- to five-segmented; eyes present or absent, reduced if present; ocelli absent. Thorax usually small, segmentation obscure or obsolete, with one or more pairs of dorsal spiracles. Wings or wing rudiments absent. Legs strongly modified for grasping hair of hosts, with single-segmented tarsi bearing single claws. Abdomen apparently nine-segmented; cerci absent; spiracles on segments three to eight or two to eight; male genitalia well developed, comparatively simple; female genitalia without an ovipositor, but with a pair of gonopods used in placing the eggs on hairs at oviposition. Eggs (called nits) normally cemented singly to hairs of host; metamorphosis absent; four instars. Bloodsucking, permanent, obligatory, ectoparasites of mammals exclusively. Size range from 0.25 mm. in a species from American flying squirrels to over 6 mm. in a species from an African wart hog.

There are nearly 250 species of sucking lice known today. No fossil forms have been found. The order is world-wide in distribution, and the host relationships are most interesting. The lice of man and primates are allied, and no louse of man is related to any louse not found on primates. The majority of species are found on rodents, hoofed animals and primates. The only carnivores harboring sucking lice are dogs (one louse species) and such marine mammals as seals, sea lions, walruses, etc. The cat family is free from sucking lice and the marsupials, bats, edentates and insectivores (with only a few exceptions) are likewise not attacked by these lice. As a continent, Australia is remarkably free from sucking lice; however, there are native Anoplura on the endemic rodentia and marine mammals. Perhaps Australia was isolated by sea from Asia before this group of lice became extensively developed and widespread. No insect parasites of the order are known. All eight of the sucking lice found in Hawaii are immigrants. Only three forms attack man.

Various members of the order play an important role in the dissemination of the causative organisms of a number of serious diseases, some of which will be discussed in appropriate places below.

#### TABULAR ANALYSIS OF THE HAWAIIAN ANOPLURA

FAMILY	GENERA	ENDEMIC GENERA	NON- ENDEMIC GENERA	SPECIES	ENDEMIC SPECIES	ADVENTIVE SPECIES
Haematopinidae	4	0	4	6	0	6
Pediculidae	2	0	2	2	0	2
Totals	6	0	6	8	0	8

Fauna 100 percent adventive.

Average number of species per genus: 1.3.

#### KEY TO THE FAMILIES OF ANOPLURA FOUND IN HAWAII

1. Eyes absent; on domesticated animals and rodents in Hawaii  
..... **Haematopinidae.**
2. Eyes present; on man in Hawaii..... **Pediculidae.**

In addition to these two families, it is probable that members of the Echinophthiridae would be found, if searched for, on the seals which occasionally are seen in the leeward Hawaiian Islands. No lice have been reported from various imported mammals in the islands, and a detailed survey would probably reveal several immigrant species not listed in this chapter.

## Family HAEMATOPINIDAE Enderlein, 1904

The members of this family are principally characterized by having the body setae arranged in rows, squamae absent, head not tubularly produced in front, tibiae without a thumb-like process and eyes absent. They are principally found on hoofed animals and rodents.

In addition to the species recorded here, it is probable that the sucking rabbit louse, *Haemodipsus ventricosus* (Denny), is also present in the islands.

## KEY TO THE SUBFAMILIES OF HAEMATOPINIDAE FOUND IN HAWAII

1. All pairs of legs more or less similar; each tarsus and tibia fitted for clasping hairs..... **Haematopininae**.  
Anterior legs smaller than other two pairs; not all of tarsi and tibiae fitted for clasping hairs..... 2
2. Pleural plates distinct on at least some abdominal segments ..... **Hoplopleurinae**.  
Pleural plates of abdominal segments wanting or obsolete...  
..... **Linognathinae**.

## Subfamily HAEMATOPININAE Enderlein, 1904

## Genus HAEMATOPINUS Leach, 1815

The species of this genus are found only on the ungulate families Suidae, Camelidae, Bovidae, Cervidae and Equidae. The largest species of sucking lice belong to this genus. For a monograph of the genus with extensive discussion, see Ferris, 1933:1-56.

These lice may be controlled by the use of 10 percent DDT dust, sodium fluoride and similar dusts; a number of standard dips, emulsions and greases (including crankcase oil) are recommended by various workers.

## KEY TO THE SPECIES OF HAEMATOPINUS FOUND IN HAWAII

1. Head comparatively short and broad, only slightly longer than broad; on cattle..... **eurysternus** (Nitzsch).  
Head two to three times as long as broad; not on cattle..... 2
2. On horses; head unusually long, one-half as long as remainder of body..... **asini** (Linnaeus).  
On swine; head less than half as long as remainder of body..  
..... **suis** (Linnaeus).

**Haematopinus asini** (Linnaeus) (fig. 168).

*Pediculus Asini* Linnaeus, 1758:612.

See Ferris, 1933:50, for synonymy and detailed discussion.

The sucking horse louse.

Oahu, Hawaii (and the other islands ?).

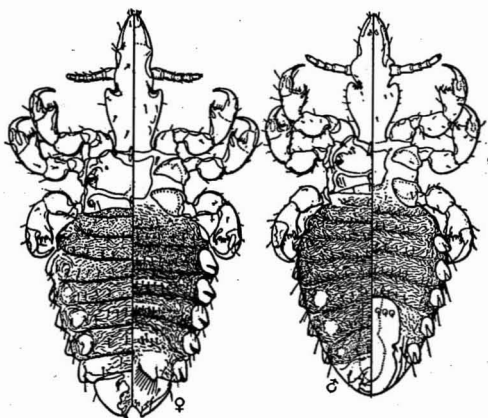


Figure 168—*Haematopinus asini* (Linnaeus), the sucking horse louse. (After Ferris, 1933.)

Immigrant. Nearly cosmopolitan. This species has not been recorded from the Territory heretofore, but I have seen specimens collected at Naalehu, Hawaii, in 1905 and have had a report of a recent infestation at Schofield Barracks on Oahu.

***Haematopinus eurysternus* (Nitzsch) (fig. 169).**

*Pediculus eurysternus* Nitzsch, 1818:305 (I have not checked this reference).

See Ferris, 1933:34, for synonymy, description, discussion and detailed illustrations.

The short-nosed ox louse.

Oahu, Hawaii (and the other islands?).

Immigrant. Nearly cosmopolitan. First recorded from the Territory by Ferris in 1933 from specimens collected from a dog (an abnormal host record) in Honolulu by the late E. M. Ehrhorn.

Host: normally cattle.

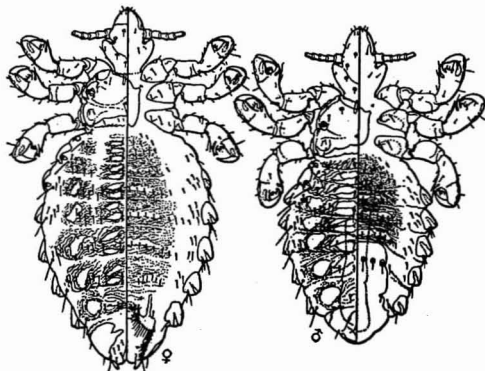


Figure 169—*Haematopinus eurysternus* (Nitzsch), the short-nosed ox louse. (After Ferris, 1933.)

Little is known of this louse in Hawaii, and it is apparently uncommon. Only one of 376 Hawaiian cattle examined by A. C. Cuckler in 1941 (1943:48) was found infested. Perhaps the best place to search for these lice on animals is along the inner edges of the ears.

***Haematopinus suis* (Linnaeus) (fig. 170).**

*Pediculus Suis* Linnaeus, 1758:611.

See Ferris, 1933:11–30, for detailed synonymy, discussion and figures; Florence, 1921:637–743, for biology, anatomy, histology.

The hog louse; Hawaiian name: “‘uku pua’a.”

Oahu, Lanai. Surely on all of the Hawaiian Islands wherever swine are found, but not definitely recorded in literature.

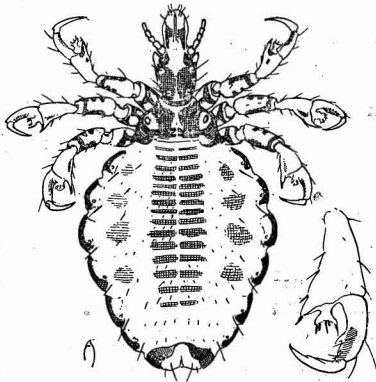


Figure 170—*Haematopinus suis* (Linnaeus), the hog louse, female. (Abernathy drawing.)

Immigrant. Cosmopolitan. The earliest Hawaiian record printed in entomological literature which I have seen is that by Illingworth in 1928 (p. 43). However, this louse was well known to the old Hawaiians, for it was brought in by them when they introduced their pigs from the South Seas during their early voyages in canoes. It is unfortunate that we do not have specimens of some of the lice originally found on the “Hawaiian” pig. Its race or variety might have supplied some interesting information.

Host: swine.

The hog louse is a vector of swine pox, and whenever that disease breaks out control measures against the louse should be undertaken immediately. Heavy infestations are not recorded frequently in Hawaii.

Subfamily HOPLOPLEURINAE

The species of this family found in Hawaii are confined to rats and mice.

## KEY TO THE GENERA OF HOPLOPLEURINAE FOUND IN HAWAII

1. With at most two transverse rows of setae on most of abdominal tergites in female, but only a single row in male; third segment of antenna of male with a process and unlike that of female ..... **Polyplax** Enderlein.
2. With three rows of setae on most of abdominal tergites in female, and two rows in male; antennae similar in both sexes and not modified in male. .... **Hoplopleura** Enderlein.

Genus **POLYPLAX** Enderlein, 1904:142

The species of this genus are almost entirely confined to rats and mice. A single species has been found in Hawaii. See Ferris (1923:183-237) for monographic details.

**Polyplax spinulosa** (Burmeister) (fig. 171).

*Pediculus spinulosus* Burmeister, 1838:8.

*Polyplax spinulosa* (Burmeister) Enderlein, 1904:142. Genotype.

For detailed synonymy and discussion, see Ferris, 1923:187, and figs. 119, 120A,D,F,H.

The spinulose rat louse.

Oahu and probably on the other islands.

Immigrant. Cosmopolitan. This species was first reported by me in 1943 (1944:200) from specimens taken earlier in Honolulu.

Hosts: According to Ferris, it is a normal parasite of *Rattus rattus* and *Rattus norvegicus* wherever they occur and is also found on other rats and mice.

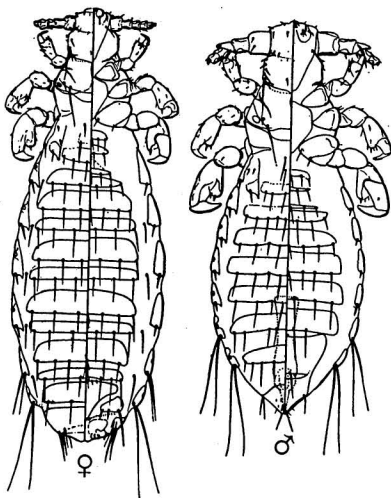


Figure 171—*Polyplax spinulosa* (Burmeister). (After Ferris, 1923.)



This louse transmits *Trypanosoma lewisi* (apparently non-pathogenic) from rat to rat, and it is a normal carrier of murine or endemic typhus fever from rat to rat.

Genus **HOPLOPLEURA** Enderlein, 1904:221

Although some species are found on other groups of mammals, the members of this genus are more characteristic of the rats, mice and squirrels (Muridae and Sciuridae). For detailed description and discussion of the genus, see Ferris, 1921:59-133. It is the largest genus of sucking lice.

**Hoplopleura oenomydis** Ferris (figs. 172; 173, a-e).

*Hoplopleura oenomydis* Ferris, 1921:82, figs. 47, 48.

*Hoplopleura pacifica* Ewing, 1924:9, figs. 1, b-c. Type locality: "Hawaiian Islands." Synonymy by Ferris, 1932:121, figs. 37, a-i; 38, a-k; 39, a-e.

The Pacific rat louse.

Oahu. Probably on the other islands, but no definite locality data assembled or available. First listed from Hawaii by Ewing (1924).

Immigrant. Also recorded from East Africa, the Philippines, Malaya, Sumatra, Celebes, Australia, Samoa, and the Marquesas Islands.

Hosts: several species of rats, including the Hawaiian rat.

Although Ewing (1924) stated that the type slide of his *H. pacifica* from the Hawaiian Islands had been placed in the Bishop Museum, the type material does not appear to be in the type collection.

See Ferris, 1932:121-127, for an extensive discussion of this species.

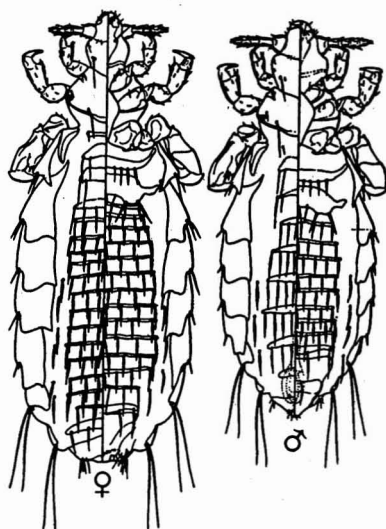


Figure 172—*Hoplopleura oenomydis* Ferris. (After Ferris, 1921.)

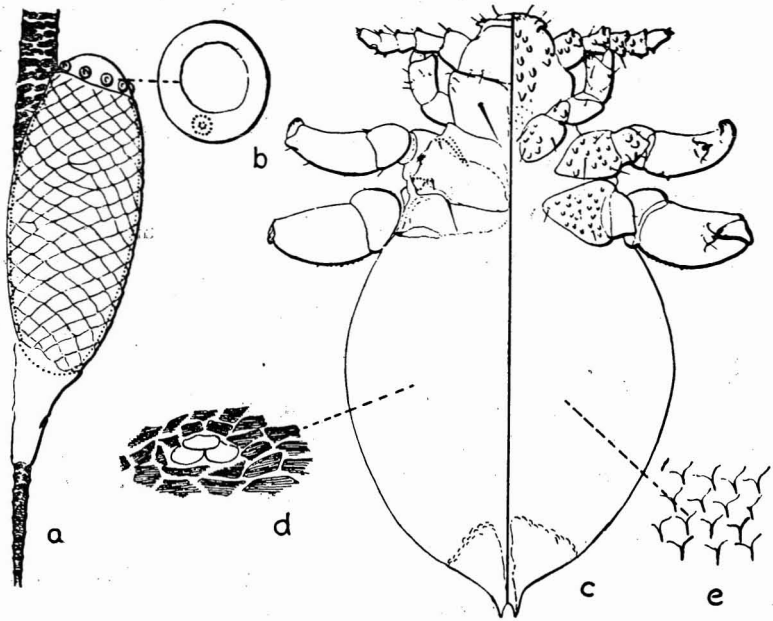


Figure 173—*Hoplopleura oenomydis* Ferris: a, egg; b, detail of egg; c, last stage of nymph; d, ornamentation of derm of dorsum; e, ornamentation of derm of venter. (After Ferris, 1932:126.)

#### Subfamily LINOGNATHINAE

#### Genus **LINOGNATHUS** Enderlein, 1905

"With the exception of a single species, which occurs on members of the family Canidae of the Order Carnivora, all the known species are from hosts of the ungulate Order Artiodactyla. Within this Order the hosts, with the single exception of one species of the family Giraffidae, are members of the family Bovidae, the cattle, sheep, goats, antelopes and similar forms. The genus may, in fact, be regarded as characteristic of this family." (Ferris, 1932:67.)

This genus can be distinguished from the other Anoplura found in Hawaii by the following combination of characters: eyes absent; antennae five-segmented, not sexually dimorphic; spiracles on abdominal segments three to eight inclusive; abdominal tergal and sternal plates absent, except for the caudal ones.

In addition to the two species below, some or all of the following *Linognathus* species may be established or may become established in Hawaii: *L. pedalis* (Osborn) on sheep, *L. stenopsis* (Burmeister) on goats, *L. vituli* (Linnaeus) on cattle.

***Linognathus africanus*** Kellogg and Paine (fig. 174).

*Linognathus africanus* Kellogg and Paine, 1911:146, pl. 4, figs. 1, 5.

For synonymy, description and figures, see Ferris, 1932:83.

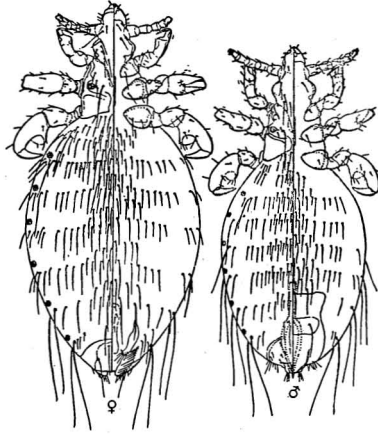


Figure 174—*Linognathus africanus* Kellogg and Paine. (After Ferris, 1932.)

The sucking goat louse.

Oahu, and probably on the other islands.

Immigrant. First collected in Hawaii by me when I found it abundant on goats at Kahala, Honolulu, in 1943. It was first described from sheep from southern Algeria, and it is now recorded from sheep and/or goats from Africa, North America, India and the Philippines; also recorded from "Klip Springer" in Africa.

Host in Hawaii: goat.

Ferris (1932:83) says, "On the basis of present knowledge it appears probable that some of the records of *L. stenopsis* from goats refer at least in part to this species." I found only specimens of this species and no *L. stenopsis* on the herd of goats from which I collected my first Hawaiian specimens, but a more detailed search might have revealed both species.

This louse was abundant and was causing considerable annoyance to goats—especially the kids, on which it was most common—when I first saw it in Honolulu.

Control: arsenical or nicotine dips or raw linseed oil worked into the infested areas is recommended; sodium fluoride and the new DDT dusts should be tried.

***Linognathus setosus* (Olfers) (fig. 175).**

*Pediculus setosus* Olfers, 1816, in "De vegetativis et animatis corporibus in corporibus animatis reperiundis commentarius," which I have not seen.

*Pediculus piliferus* Burmeister, 1838:13.

Genotype of *Linognathus*.

For detailed synonymy, discussion and illustrations, see Ferris, 1932:70.

The sucking dog louse.

Oahu (and the other islands?).

Immigrant. Cosmopolitan. Not recorded in Hawaiian literature heretofore.

Host: dog.

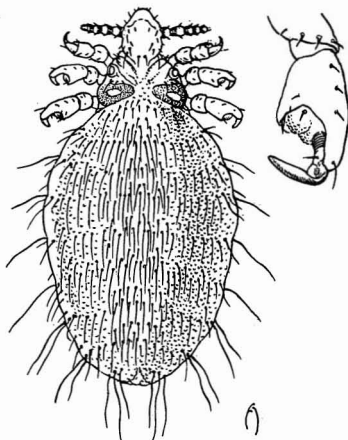


Figure 175—*Linognathus setosus* (Olfers). (Abernathy drawing.)

### Family PEDICULIDAE Samouelle, 1819

The members of this family share the characters of the Haematopinidae in having the body setae arranged in definite rows, scales wanting, head not tubularly produced in front, tibiae without a thumb-like process, but the eyes are present and well pigmented.

It is evolutionarily significant that the Pediculidae are restricted to men, monkeys and apes. No species of the family lives on any but a primate host.

#### KEY TO THE SUBFAMILIES OF PEDICULIDAE

1. Fore legs fully as stout as other two pairs; abdomen distinctly segmented, lateral tubercles absent; thorax narrower than abdomen (fig. 176) ..... **Pediculinae.**
2. Fore legs distinctly more slender than other pairs; abdomen not distinctly segmented, segments five to eight with conspicuous lateral tubercles; thorax broader than abdomen (fig. 177) ..... **Phthirinae.**

#### Subfamily PEDICULINAE Enderlein, 1904

Although none has been yet recorded from Hawaii, it is possible that one or more species of *Pedicinus* are present on monkeys in the local animal park. To my knowledge, these animals have not been searched for lice.

#### Genus **PEDICULUS** Linnaeus, 1758:610

For a scholarly dissertation on the genus, replete with excellent illustrations, see Ferris, 1935:8-76, figs. 306-334, pls. 1-3.

The genus *Pediculus* is taxonomically difficult and confusing. The animals are variable, and a number of "species" and "varieties" have been described. After

long and careful study, Ferris (1935) concludes that there are but three recognizable, described, full species. One of these is the normal ectoparasite of man, another is found on New World monkeys, and the third is from a chimpanzee.

***Pediculus humanus humanus* Linnaeus.**

*Pediculus humanus* Linnaeus, 1758:610.

This form has also been called *corporis* and *vestimenti* by various authors.

The body louse, gray back, cootie; Hawaiian name: "uku kapa." "Kapa" is the Hawaiian spelling of "tapa," or bark cloth, which was used for clothing and bedding by the old Hawaiians.

***Pediculus humanus capitis* Degeer (fig. 176).**

*Pediculus humanus* variety *capitis* Degeer, 1778:67.

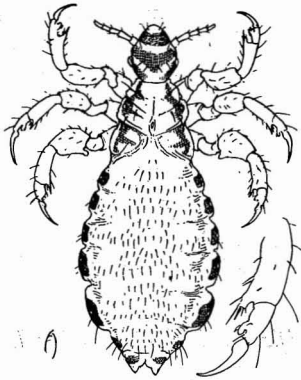


Figure 176—*Pediculus humanus capitis* Degeer, the human head louse, female. (Abernathy drawing.)

The head louse; Hawaiian name: "uku-po'o"; egg (nit), "liha."

For a detailed, scholarly discussion, complete synonymy and abundant illustrations, see Ferris, 1935:17-62, figs. 306-327, pls. 1-3. For anatomy, biology, medical importance and control, the excellent volume *The Louse* by Buxton, 1939, is highly recommended and it will give a key to literature for those who wish more detailed information than that included herein.

Immigrant. Cosmopolitan. Brought to Hawaii with the first aboriginal immigrants.

The human louse has been associated with man since the "beginning," and it is found with every race of man throughout the world, no matter what remote area he has colonized. Occasionally, specimens are found on primates in captivity and occasionally are taken from domesticated animals, but these are abnormal and unsuitable hosts.

Perhaps the earliest reference to human lice in Hawaiian literature is that made

by the missionary C. S. Stewart in 1828 (*Journal of a Residence in the Sandwich Islands, during the Years 1823, 1824 and 1825*. London, 1828). Stewart wrote that dozens of head lice

may, at any time, be seen sporting among the decorated locks of ignoble heads; while not infrequently, a privileged few wend their way through the garlands of princes of the blood, or triumphantly mount the coronets of majesty itself.

As to the servants of the chief and the common people, we think ourselves fortunate indeed, if, after a call of a few minutes, we do not find living testimonies of their visit, on our mats and floors, and even on our clothes and persons! The bare relation of the fact, without the experience of it, is sufficiently shocking. But the half is not told; and, I scarce dare let the truth, here, run to its climax. The lower classes not only suffer their heads and tapas to harbour these vermin; but they openly and unblushingly eat them! Yet so fastidious are they in point of cleanliness, that an emetic could scarce be more efficaciously administered than to cause them to eat from a dish in which a fly had been drowned!

Inasmuch as the old Hawaiians had lice, it is natural to expect that they would have stories about them. There are a number of Hawaiian place names that refer to lice, for example, Wainaukepo'o in Kau, Hawaii, refers to a place where it used to be the custom to rest by a stream side for purposes of delousing the head. A Hawaiian riddle runs:

"Ku'u kanaka holoholo iloko o ke 'uki," or, My man who runs around among the "uki" grass. Answer: a head louse.

The act of delousing is called "nauke" in Hawaiian. If the lice are killed by crushing between the fingernails, the process is called "ho'u'ina" (to snap), but if they are killed by biting, as is done by many peoples, that method is termed "aki" (to nip with the teeth). (I am indebted to Mrs. Kawena Pukui for these notes.)

#### *Pacific Native Names for Lice*

The word "uku (kutu)," meaning louse, is widespread in many Pacific dialects. The following representative list is of interest and shows the continuity of the name over a vast area:

Malay—kutu	Futuna—kutu
Java—kutu	Tonga—kutu
Philippines—katu, cuto	Samoa—'utu
New Britain—utu	Rarotonga—kutu
New Hebrides—gutu, kutu	Tahiti—'utu
Santa Cruz—kutu	Tuamotu—gutu
New Zealand—kutu	Marquesas—kutu
Fiji—kutu	Mangareva—kutu

Parasites: no insect parasites and no effective bacterial, fungal or protozoan parasites are known.

Predators: man alone; but some peoples delouse their vestments by exposing them to ants which may be efficient "delousers."

There is considerable question as to what are the best terms to apply to the forms of *Pediculus humanus*. They might be called "races," "varieties," "forms" or

not named. Ferris (1935:51 [577]) says, "the bulk of the evidence supports clearly the view that these two forms are merely extremes of a single species; that every combination of and intergradation between their characters exists...."

Head lice and body lice may or may not be distinguishable, because of the variability of the characters used to separate them. In general, the antennae of the body louse are longer and more slender than those of the head louse; body lice are, on the average, larger than head lice, and the lateral notches marking the segments of the abdomen may be more clearly defined in head lice. However, these distinctions are variable and are often indistinct and are not to be relied upon entirely. Lice answering the description of head lice may at times be found acting as body lice. The best distinction appears to be in their habits. Head lice usually deposit their eggs on hair, whereas body lice normally lay theirs in clothing. Head lice and body lice can be crossed easily and the offspring remain fertile through succeeding generations. Head lice forced to live on the body will ultimately give rise to generations which have assumed the characteristics of body lice. It is worthy of note, however, that there appear to be certain differences in the genetic make-up of the forms, for it has been reported that the percentage of intersexes rises distinctly in hybrid populations. Detailed genetical studies remain to be undertaken.

**Biology:** To my knowledge, no biological studies of human lice have been made in Hawaii. The oval, pale-yellowish eggs which are cemented to hairs or fibers of clothing are about 0.3 mm. wide and 0.8 mm. long. In Hawaii they probably hatch in eight to ten days. There are four instars; the nymphs molt thrice. The duration of the nymphal life of the head louse is about eight days, and is somewhat longer for the body louse. On the average, adults live about a month, but may live from one week to more than seven weeks. It is probable that the adults can live only three to five days when separated from their hosts in Hawaii, and the length of life is shortest in hot weather. Copulation may take place a few hours after the adult stage is reached, and egg laying begins about four days after the last molt. The head louse most commonly lays its eggs (called "nits") near the base of hairs behind the ears of its host, but the whole scalp may be affected, and even the eyebrows and eyelashes are at times infested. The body louse may lay its eggs on body hairs, but it most commonly oviposits on underclothing and has a special liking for the region of the nape of the neck. It is most common to find ten or fewer lice on a human head, but there may be hundreds or even a thousand or more present (see Buxton, 1939, for detailed discussion). Among some negligent peoples, individuals may be heavily infested. On some primitive tropical people who wear few clothes, body lice have been reported in abundance from their beads and loin cloths.

Pediculosis (lousiness) is now usually the result of squalor or abnormal crowding of people, at least in Western civilization. The rise in the general standard of living and personal cleanliness has had much to do with the elimination of human lice in modern society. However, lice remain among the most dangerous ectoparasites of man. Many people make little effort to control them, and through their ignorance of disease transmission, are largely unaware of the actual and potential dangers

of being lousy. Wherever there are dirty, unkempt, crowded people whose general level of education and personal hygiene is low, or when times of abnormal stress, poverty and war drastically change the living habits of large and small populations, lousiness usually obtains. Wartime conditions are obviously most conducive to pediculid development and dispersal.

Although pediculosis was at one time prevalent in Hawaii, we do not now hear much more about it than in the better mainland areas of the United States. It used to be a common sight to see people unconcernedly delousing one another in Hawaii. The head louse is not uncommonly found among school children now; and delousing may be on occasion resorted to by school nurses. On occasion, head louse infestations of more than 10 percent have been reported from certain schools in Honolulu. Unfortunately, no general statistics on pediculosis are available in the islands. It is of considerable interest that the body louse is rarely encountered in Hawaii, evidently because of the cleanly habits of most of our people who insist upon frequent baths and fresh, well-laundered, clean clothes. It is noteworthy that it is a tradition among the Japanese always to bathe before going to bed. The scarcity of body lice among the Malayan peoples has been noted by other authors. With World War II came an increase in lousiness among Hawaiian school children—evidently because less attention was given children by “war worker” parents and because of more crowded conditions and inadequate housing.

Medical importance: The reader is referred to the several textbooks on medical entomology and parasitology and to Buxton (1939) for much more extensive discussion and detailed reviews of human lice in relation to disease than will be given here.

In many regions of the world, human lice transmit serious diseases, and although we in Hawaii are most fortunate in not now being plagued by louse-borne disease, it will be worth-while to review these diseases briefly here.

The effect of louse bites on human hosts varies. Some few people hardly notice the feeding of lice, whereas others may be very sensitive. Some rare individuals are immune to louse attack, because lice refuse to feed upon them. However, the feeding of lice usually causes definite reactions. On most people, small, reddish papules appear a few hours after each bite, and these itch and cause much scratching. Sensitive individuals develop a distinct rash. It has been shown that the salivary secretions of the lice have a definite toxic effect on the host. When infestation is heavy, general systemic upsets may occur; there may be fever, adenitis, skin eruptions, anemia, a decided feeling of fatigue, insomnia and irritability. Scratching of the itching bites frequently results in secondary infestations by such micro-organisms as staphylococci and fungi and may lead to extensive dermatitis or impetigo. Some workers have shown that tropical impetigo may be carried from person to person by lice. Individuals with prolonged pediculosis may develop a thickened, roughened, pigmented skin (melanoderma) which has been termed “vagabonds’ disease.” It is of interest to note that experiments with rats show that vitamin B deficiency is conducive to lousiness.



It has been shown that lice may transmit some diseases mechanically. One disease shown to be so transmitted on occasion is bubonic plague. Chandler (1940:533) says, "Lice do not transmit plague by their bites, but may do so when crushed. Natives in Java kill lice by mashing them against the head of the host, which should make infection through the scratched sores on the head very easy. In Ecuador and Peru natives are said to kill lice by crushing them between the teeth; there is much more danger involved when man bites louse than when louse bites man."

Three serious diseases are transmitted by lice: epidemic typhus, trench fever and relapsing fever (epidemic typhus must not be confused with endemic or murine typhus, which is established in Hawaii). Most fortunately, none of these diseases has become established in Hawaii, but it will be worth-while briefly to review them here.

Epidemic typhus is caused by *Rickettsia prowazeki* (rickettsias are considered to be allied to bacteria). It is transmitted from man to man by lice, and is essentially a disease of certain temperate regions. The micro-organisms develop in great numbers in the epithelial cells of the midgut of the louse; the cells eventually rupture and the *Rickettsia* pass out with the louse excreta. Man is not infected through the bite of the louse, but normal infection is caused by scratching the bite and inoculating the abraded skin surface with infected louse feces which are deposited on the skin. It has been shown that the disease organisms will withstand long periods of desiccation in louse excreta, and it is believed that it is possible to acquire the disease through air-borne louse feces. The incubation period in man is about 10 days and the course of the disease is from about 10 days to over three weeks. The mortality rate may be 15 to 75 percent. Herms (1939:111) says, "Wherever human beings are concentrated in close quarters, especially in times of war and famine, this disease may become rampant. The disease is characterized by a high fever, backache, headache, bronchial disturbances, a congested face... a brick-red mottled eruption which later spreads, forming brownish irregular blotches."

Buxton (1939:66) presents a graph that shows a remarkable and rapid reduction of the disease from a few thousand deaths in England in 1870 to none in the years 1919 to 1937. He attributes this disappearance to the reduction of pediculosis. Riley and Johannsen (1932:132) note that

Until 1870 the disease was endemic and in some cases even prevalent in most of the countries of Europe, but from that period until the World War it was almost unnoted. The crowding of soldiers and prisoners of war and the movements of great masses of homeless people under insanitary conditions furnished again ideal conditions for the development of the disease, and its ravages constituted the major sanitary problem of the time. It is established that during the war over 10,000,000 Russians had typhus and that of these over 2,000,000 died. In April of 1915 it was reported that Serbians were dying at the rate of 9,000 per day. Medical men and nurses were no more exempt than was the general populace. Out of 460 Serbian doctors 360 were attacked during this outbreak and more than 120 died. In Poland conditions were even worse....

Trench fever is also caused by a *Rickettsia*, but instead of the causative organism (*Rickettsia quintana* [*R. pediculi*]) developing intracellularly in the louse intestine,

it multiplies in the lumen of the midgut. "This disease was so common during World War I as to cause more sickness than any other disease except scabies, though it was a relatively mild disease. Before the war it was unknown, and it has fallen into complete obscurity since then." (Chandler, 1940:214.) The transmission of the disease is accomplished by scratching the disease organisms from louse feces into the skin. For detailed studies of this disease, see R. P. Strong et al., 1918, and David Bruce, 1921.

Relapsing fevers are transmitted to man by ticks or lice. Epidemic relapsing fever is caused by spirochaetes; the louse-borne types are strains of *Spirochaeta recurrentis*. The epidemic louse-borne type is more important than the "sporadic" or tick-borne type. After a blood meal by the louse, the spirochaetes pass through the intestines and multiply in the haemocoel of the louse. They do not escape from the haemocoel via the rostrum or salivary secretions and are not passed out with the feces. It is, therefore, necessary that a louse or lice be crushed on one's person and the spirochaetes inoculated into an abrasion or mucous membrane before the disease can be transmitted from louse to man. At present the louse-borne form of the disease appears to be absent from North America, western Europe, and Oceania, but present in Central and South America, North Africa, eastern Europe, and Asia.

Control of human lice: Lice are spread by contact, and a knowledge of their habits and methods of dispersal will aid greatly in their control. Fortunately for us in Hawaii, the body louse is rarely encountered. The promiscuous use of head-gear, combs, brushes and clothing invites lousiness, even here in Hawaii. Those who may have to deal with large-scale delousing projects are referred to the standard textbooks and technical reports for detailed control procedure, and we may briefly outline suggested control measures for Hawaii. Control begins with cleanliness, and all lousy individuals should be given initial, thorough bathings and their clothes washed or fumigated.

The use of 10 percent DDT dust gave spectacular control of lice in recent applications in war areas, and its use may become more general in the postwar period. It is dusted into the hair of the infested individual and applied generously to under-clothing. Its use may replace most of the following control methods.

Control of head lice in males can be facilitated by cutting the hair short or by shaving the head when such a procedure is indicated. However, in our society the stigma carried by one whose head has been shaved because of pediculosis must be considered.

Trembley (1943:795) highly recommends the use of derris, and says, "Derris is an effective material for combating the head louse...and the pubic louse.... The application of derris powder to louse-infested heads is a practical method of controlling head lice, and if persistently and generally applied should result in eradication [of lice] from a community...." It is suggested that about one teaspoon of finely ground derris containing 3 percent of rotenone be applied with a salt shaker and worked well into the hair, care being taken not to get the powder into the eyes; the hair should not be washed for several days following treatment.

The dusting should be repeated two or three times for effective control, because the dust does not kill the eggs. The material can be used similarly for pubic lice, but too much dust should not be applied, because it causes severe irritation to some people. The dust can be colored so that it will not be conspicuous on blond or brunette hair, thus enabling children to go to school without embarrassment while under treatment.

A new formula showing much promise has been brought to attention recently. It consists of an emulsion of 5 percent isobornyl thiocynoacetate and 0.6 percent dioctyl sodium sulfosuccinate. About two ounces of the fluid are lathered into the hair and left for five or ten minutes; the hair is then combed and allowed to dry. The next day the dried emulsion is washed out with soap and water. The poison irritates the eyes and care should be taken not to get any in the eyes. This treatment kills both eggs and adult lice, and usually control is complete with a single application.

A mixture of equal parts of kerosene and cottonseed oil or olive oil is an effective and simple delousing agent; the hair is thoroughly saturated with the mixture and then enclosed in a bathing cap or a tight towel wrapping and left for several hours. Xylene (xylol) in vaseline (one-quarter xylene in three-quarters vaseline) has been found to be good, but the material may irritate the skin. Another simple method recommended is to saturate the hair with 70 percent ethyl alcohol and to enclose the hair in a bathing cap for an hour or more. (Caution: keep in mind the inflammability of the materials used!) After these treatments, the hair should be washed well with warm, soapy water. Careful and thorough use of a fine-tooth comb is also recommended.

When infestations of body lice are encountered, the following procedure might be followed: Remove all clothing and have it thoroughly washed and ironed or dry-cleaned and pressed; treat bedclothing, towels, etc., similarly. It is recommended that all infested or possibly infested material be fumigated before laundering. Clothes may be fumigated at home by placing them in a tight box, can or bin and scattering ample amounts of naphthalene (mothball) flakes or paradichlorobenzene crystals among the clothing and leaving tightly closed for a day or more. Carbon tetrachloride (sold under such trade names as "Carbona," etc., and used in certain types of fire extinguishers) is an adequate fumigant which is cheap, non-explosive and simple to use. However, very hot water will kill all lice and eggs instantly. Exposure to direct sunlight on hot days will usually kill the lice in clothing if it is spread out well. It may be advisable to treat rooms in which heavily infested people have lived. Probably a simple closing of the rooms for about three weeks in Hawaii will result in the death of all the lice. Proper fumigation is recommended, but fumigation is often not feasible or possible. If methyl-bromide or cyanide fumigation is impossible, carbon tetrachloride might be used. Latta and Yeomans (1943:402) outline methods and equipment used for methyl-bromide fumigation of clothing infested by lice. Buxton (1939:90) recommends spraying the floors and walls of infested rooms with a kerosene emulsion made as follows: dissolve three parts by weight of soft soap in 15 parts water; while agitating the

liquid, add kerosene until no more will emulsify. This concentrate can be stored and used as a spray diluted one part to 20 parts of water.

It must be remembered that satisfactory control cannot be attained unless the source of lice infestation is destroyed. It does no long-term good to delouse children at school, only to have them become reinfested in their own homes. Physicians and public health nurses should follow up infestations and try their best to apply control where it will do the most good.

#### Subfamily PHTHIRINAE

*Phthiridae* Ewing, 1929:132.

*Phthiriidae* Brues and Melander, 1932.

This group has been considered by many authors to belong to the true Pediculidae, and they have not separated the genus from *Pediculus* by any suprageneric ranking. Ewing in 1929, however, established the new family Phthiridae (not Phthiriidae) for the crab louse principally because of the fusion of the abdominal segments and the presence of lateral abdominal tubercle-like processes. Ferris (1935:77) says, "Ewing has placed it (*Phthirus*) in a family, Phthiriidae, (Phthiridae) by itself. While it is indeed a peculiar genus, such a separation seems to remove it unnecessarily far from its relatives, which are evidently among the other Primate-infesting forms." The opinions of each author bear weight. I feel that perhaps a compromise between the two opinions is justified, and I am, therefore, placing the genus *Phthirus* in the Phthirinae—a subfamily of the Pediculidae.

This group contains one genus, which in turn is monotypic or may contain a second species.

#### Genus PHTHIRUS Leach, 1815

*Phthirus*, of authors.

This genus contains one well-known ectoparasite of man and an imperfectly known "species" described from eggs and first-stage nymphs from the Belgian Congo from *Gorilla berengeri*.

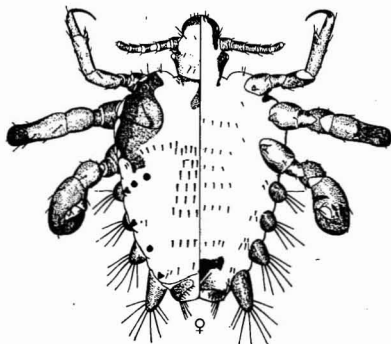


Figure 177—*Phthirus pubis* (Linnaeus), the crab louse. (After Ferris, 1935.)

***Phthirus pubis* (Linnaeus) (fig. 177).**

*Pediculus Pubis* Linnaeus, 1758:611.

*Phthirus inguinalis* Leach, 1815:77 (Edinburgh Encyclopaedia, vol. 9. I have not checked this reference).

For detailed synonymy, illustrations, descriptions and discussion, see Ferris, 1935:77-82, figs. 335-337.

Genotype of *Phthirus*.

The pubic louse, crab louse; Hawaiian name: "uku-papa."

Immigrant. Cosmopolitan. Probably imported to the Hawaiian Islands by early European voyagers, but not present in old Hawaii.

This louse cannot be confused with any other; its shape alone is diagnostic. It is much less common than *Pediculus*, but perhaps it may come to the attention of local physicians more often than *Pediculus* because of the position it occupies on its host.

Biology: Much less work has been done on the life history and habits of the crab louse than on the body and head lice. Man is the only host upon which the louse is known to be able to breed successfully. The eggs are glued only to hairs, and they have an incubation period of six to eight days. The adult stage is reached in 13 to 17 days after eclosion. Nuttall found the egg-to-egg history to take 22 to 27 days. The mature lice are thought to live not more than a month, and larvae and adults die within a day or two after removal from the host. The adults are quite sedentary and may cling to the same hairs and feed continuously for long periods of time. The lice are most commonly found in the pubic and peri-anal area, but no part of the body is absolutely exempt from attack. Although the heads of infants may become infested, crab lice are rarely found on the heads of adults. Reports of individuals infested from ankles to eyebrows are on record. Occasionally the eyelashes may be heavily infested.

The reactions of persons to the bites of the crab louse vary, as do man's reactions to *Pediculus*. The feeding of the lice usually causes a decided itching, with subsequent severe scratching which may lead to secondary infections. The salivary products of the louse cause a bluish discoloration of the tissue. "The 'blue spots' ... are 0.2 mm. to 3.0 cm. in diameter, with an irregular outline. They are painless, do not disappear on pressure, and appear to be in the deeper tissues. They appear some hours after the crab louse has bitten and last for a number of days. They do not invariably follow the bite of this insect, but when they develop they are characteristic of *Phthirus*, not *Pediculus*..." Buxton, 1939:97 (after Nuttall, 1918).

Hermes (1939:107) calls infestation by *Phthirus* "phthiriasis"; "pubic pediculosis" is also used.

The role played in the transmission of disease by this louse is unknown, but it does not appear to be an important vector.

The most common method of transmission of the crab louse appears to be through sexual intercourse. But it may be transmitted in other ways. Many victims are infested from toilet seats and occasionally from bedding or simply from contact with infested clothing or individuals.

Control: 10 percent DDT dust is an efficient insecticide. The clipping or shaving of the hair in the infested areas is usually recommended, but this may lead to irritation to such active persons as soldiers during wartime. The xylene ointment described under *Pediculus* is recommended. Derris powder has been found effective, but some people may be irritated by it. Mercury compounds should be avoided; they are dangerous and are not good insecticides. When the eyelashes are infested, a local anesthetic may be applied and the lice picked off individually by the use of forceps. Thorough washing with hot, soapy water is always indicated for every infestation and following every treatment.

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## Order **ODONATA** Fabricius, 1793

(Odonata is thought to be an abbreviation of Odontognatha; *odous*, a tooth, and *gnathos*, a jaw, thus referring to the toothed maxillae)

Dragonflies, Damselflies

(Hawaiian names: "pinao"; "pinao-ula")

Head hypognathous, large, exposed, free, globular or dumbbell shaped, highly mobile, attached to a very slender neck; labrum large; mandibles strongly developed, fitted for biting and chewing, with well-developed incisor and molar teeth; maxillae with unsegmented palpi; internal lobe, or mala, strongly and conspicuously toothed; labium peculiarly evolved, mentum with two side pieces (*squamae* or *squames*) representing the palpigers, palpi two-segmented, the proximal segment broad, terminating in a hook-like lobe, the distal segment hook-like and movable in all forms excepting the Libellulidae, in which group it and the hook of the proximal segment are lacking; compound eyes very large; three ocelli always present; antennae shorter than head, fused to form a peculiar pterothorax which is inclined backward with the leg position shifted cephalad, the wing position caudad, terga reduced, pleura greatly developed, anterior part of mesothorax which appears to be the dorsum, really formed by the peculiarly extended mesepisterna; legs fitted for grasping and climbing, but not well-fitted for walking, grouped close under the head where they aid in capturing, holding and transferring food to the mouth, trochanters divided into two parts, tarsi three-segmented, claws paired, usually toothed, empodium vestigial; four large, well-developed wings always present, subequal in size, usually held either horizontally at right angles to body or folded vertically above abdomen, complexly net-veined, membrane bare, stiff. Abdomen slender, greatly elongate, 10 complete segments visible, segments 11 and 12 rudimentary, cerci (called superior anal appendages) well developed; ovipositor primitive, present in all Zygoptera, but absent in some Anisoptera; gonopore of male situated on segment nine, but functional penis and accessory organs peculiarly located on segment two. Metamorphosis gradual, incomplete; eggs oblong or ovate and dropped free in water (exophytic oviposition) or elongated and inserted in plant tissues by use of well-developed ovipositor (endophytic oviposition), some non-Hawaiian forms insert their eggs in mud; larvae, called naiads or nymphs, aquatic with a few endemic exceptions, all predaceous; the number of instars is stated to be between 11 and 15.

The oldest fossil species known have been described from Lower Permian rocks. Some of the ancient forms (Carboniferous) had wing expanses of more than two feet. There are now about 3,500 described living species. The order is cosmopolitan, with the greatest modern development in the Neotropical Region. Most of the species are diurnal heliophiles as adults, but some Indo-Pacific and American forms are crepuscular or nocturnal.

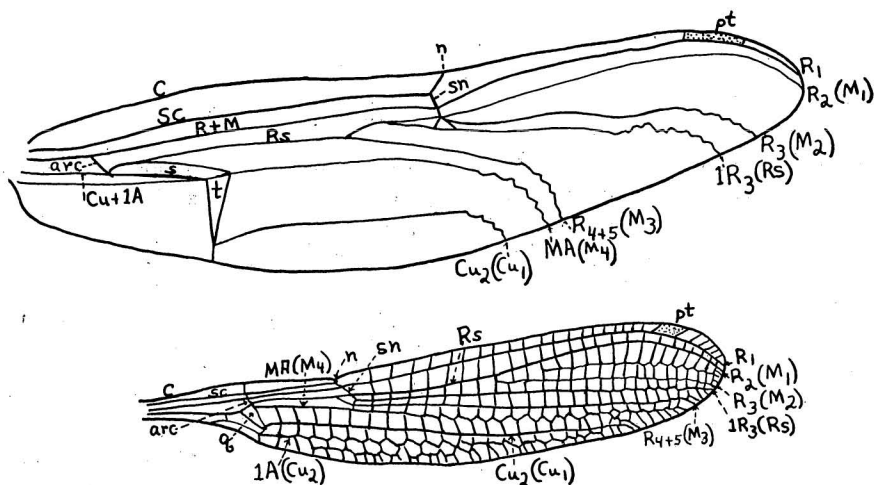


Figure 178—Wing venation of Odonata. Upper figure is the fore wing of a dragonfly (Anisoptera) with the cross-veins omitted to show the principal veins. The lower figure is of a *Megalagrion* damselfly (Zygoptera). The nomenclature is based upon that of Tillyard with an alternate system in parentheses. 1A, first anal; arc, arcus; C, costa; Cu+1A, cubito-anal; Cu<sub>2</sub>, second cubitus; MA, anterior median; n, nodus; q, quadrangle; pt, pterostigma; R<sub>1</sub>, radius (main stem); R+M, radio-median; Rs, radial sector; R<sub>2</sub>, R<sub>3</sub>, 1R<sub>3</sub>, R<sub>4+5</sub>, all branches of radial sector; s, supratriangle; sc, subcosta; sn, subnodus; t, triangle.

The organs and method of copulation are peculiar. In fact, they are unique among animals. The genital pore of the male is situated on the ninth abdominal sternite, but the functional intromittent organ is a strange secondary development situated on the venter of the second abdominal segment. When ready to copulate, the male bends his abdomen under and forward and transfers spermatozoa from the gonopore to a vesicle near the "penis" on the second ventrite. During copulation the male grasps the female with his caudal claspers by the top of the thorax, neck or head, and she swings her abdomen forward so that her gonopore comes in contact with the secondary copulatory organ complex of the male. Copulation takes place while on the wing, or settled, and we speak of copulating pairs as "tandems."

The adults of most species capture all their food while on the wing, but some of our species have been observed to pick their prey off plants and the ground. The anteriorly placed, modified legs form a catching basket. The nymphs (which are called "olopelopes" in Hawaiian) have a remarkable folding, prehensile labium which can be shot out with great speed to capture prey.

The student is referred to the standard textbooks for more detailed discussions of the order.

There are 34 forms found in Hawaii. Of this total, five are immigrants and 29 are endemic. The native species include a monotypic genus, *Nesogonia*, in the Libellulidae; a geologically recent derivative of the Holarctic *Sympetrum*; a single native species of the cosmopolitan *Anax*; and 27 forms belonging to *Megalagrion*,

an endemic genus derived from, and closely similar to, the Oriental-Pacific *Pseudagrion*.

These data may be compared with the Odonata fauna of Samoa, where 29 forms are found. There we find that the Zygoptera are represented by 13 forms. Three of the Zygoptera are immigrant, one is a *Pseudagrion* and one an *Agriocnemis*. Five of the remaining eight belong to *Ischnura*, while the other three belong to local segregates of *Ischnura* which have been assigned two generic names. Thus, in Samoa, *Ischnura* has a comparable, if less extensive, development to the Hawaiian *Megalagrion*. The Samoan dragonflies are much more numerous than the Hawaiian forms. The Anisoptera are there represented by 16 forms, belonging to 12 genera; two of these forms are thought to be endemic and 14 are immigrants. The proximity of Samoa to Fiji and other island steppingstones to Papua and Australia accounts for the richer generic representation and the high percentage of immigrants.

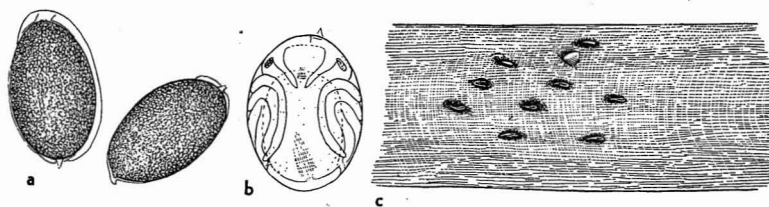


Figure 179—Eggs of Odonata: a, eggs of *Nesogonia blackburni* (McLachlan), which are laid free in water; b, the same, one day before hatching; c, part of a stem of *Herpestes monieria* showing egg punctures and the protruding parts of the shells of hatched eggs of *Anax junius* (Drury). (From drawings by F. X. Williams.)

#### TABULAR ANALYSIS OF THE HAWAIIAN ODONATA

FAMILY	GENERA	ENDEMIC GENERA	NON- ENDEMIC GENERA	SPECIES	ENDEMIC SPECIES	ADVENTIVE SPECIES
Aeshnidae	1	0	1	2	1	1
Libellulidae	3	1	2	3	1	2
Coenagriidae	3	1	2	29	27	2
Totals	7	2	5	34	29	5

Percentage of endemism in native group: genera, 66⅔ percent; species, 100 percent.

Percentage of present-day fauna native: 85 percent.

Percentage of present-day fauna adventive: 14 percent.

Average number of forms per genus in native group: 9.7.

Average number of forms per genus in adventive group: 1.

#### KEY TO THE SUBORDERS OF ODONATA FOUND IN HAWAII

1. Adults ..... 2
- Larvae ..... 3

- 2(1). Wings held open and horizontal when at rest, hind pair broader near base than fore pair; eyes very large and touching or almost touching on top of head. . . . . **Anisoptera.**  
 Wings held vertical and close together over back when at rest, hind pair not broader near base than fore pair; eyes widely separated above. . . . . **Zygoptera.**
- 3(1). Gills enclosed in rectum, not externally visible; swim by squirting water from anus ("jet propulsion") . . . . **Anisoptera.**  
 Gills caudal and external, plainly visible; swim by wriggling and sculling with gills. . . . . **Zygoptera.**

### Suborder ANISOPTERA Selys-Longchamps, 1834

#### Dragonflies

(Hawaiian name: "pinao")

Wings held horizontally or depressed in repose; hind wing always more or less considerably broader than fore wing near base; radius branched, radial sector crossing two branches of media; oblique vein and bridge present; discoidal cell differentiated into triangle and supertriangle. Eyes large, often meeting mid-dorsally, never separated by a space greater than their own diameter. Labium variable. Male with two superior and one inferior anal appendages, all placed dorsally above anus (the inferior may be bifid or trifid); penis jointed; female with superior appendages but no inferior appendage, ovipositor variable. Larvae with gills in rectum (proctobranchiate); anus closed by an anal pyramid formed of three spines, one medio-dorsal and two lateral; gizzard with four to eight dental folds. (Modified from Tillyard, 1917:259.)

Of the two suborders of Odonata, this is the least developed in the islands. There are five species representing four genera here, but only two of these are endemic, and these two species are geologically recent derivatives of widespread genera or species.

The dragonflies are much more active and much faster fliers than the damselflies. The adults of all our species emerge from their nymphal cases in the morning hours.

#### KEY TO THE SUPERFAMILIES OF ANISOPTERA

1. Adults . . . . . 2  
 Naiads . . . . . 3
- 2(1). Triangles of both fore and hind wings equidistant from arculus . . . . . **Aeshnoidea.**  
 Triangles of hind wings nearer arculus than those of fore wings . . . . . **Libelluloidea.**
- 3(1). Labium flat, not concealing face; lateral lobes curved, mandible-like . . . . . **Aeshnoidea.**  
 Labium spoon-shaped, covering most of face (up to antennae); lateral lobes subtriangular and fitting close against sides of apex. . . . . **Libelluloidea.**

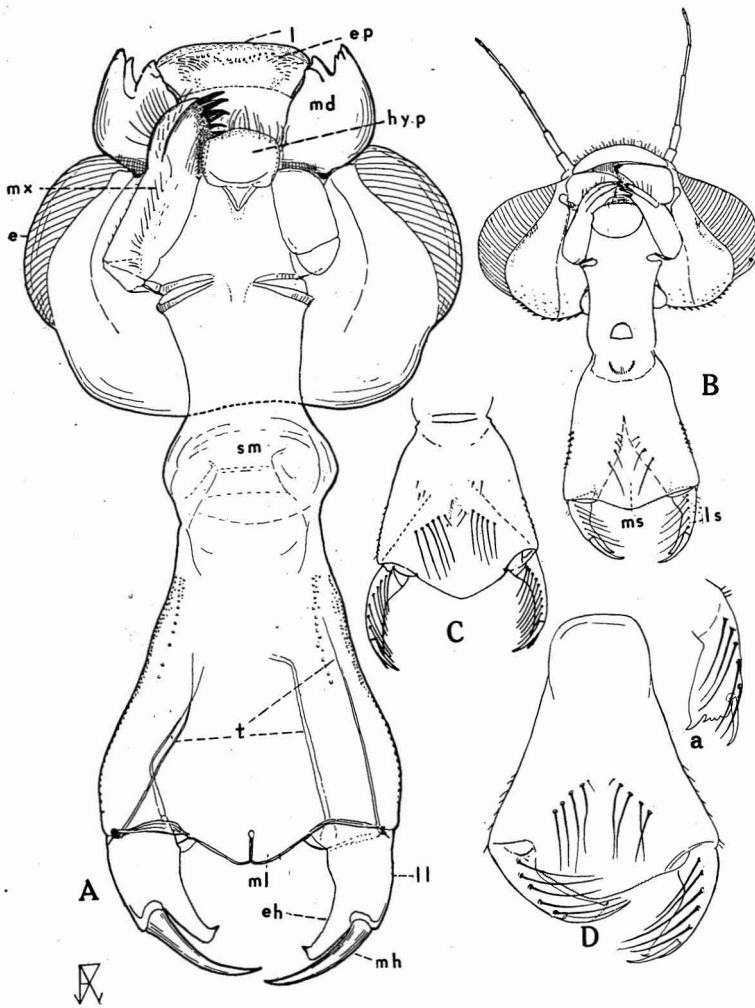


Figure 180—Cephalic details of some Odonata naiads. **A**, *Anax strenuus* Hagen, underside of head with "mask" unfolded, left maxilla removed: **a**, eye; **eh**, end hook; **ep**, epipharynx; **hyp**, hypopharynx; **l**, labrum; **ll**, lateral lobe; **m**, mentum; **md**, mandible; **mh**, movable hook; **ml**, median lobe; **mx**, right maxilla; **t**, tendons; **sm**, submentum. **B**, *Megalagrion leptodemas* (Perkins), underside of head with labrum unfolded: **ms**, median setae of median lobe; **ls**, setae of lateral lobe. **C**, *Megalagrion xanthomelas* (Selys-Longchamps), inner view of mentum of "mask." **D**, The same of *Enallagma civile* (Hagen): **a**, inner face of lateral lobe. (Rearranged from original figures for Williams, 1936.)



## Superfamily AESHNOIDEA Selys-Longchamps, 1840

## Family AESHNIDAE Burmeister, 1839

## The Darners

Opinion Number 34, rendered by the International Committee of Zoological Nomenclature reads: "Aeschna vs. Aeshna.—Since evidence of derivation of the word is not contained in the original publication, the original spelling of Aeshna should be preserved." Therefore, the spelling *Aeshna* is used here.

## Subfamily AESHNINAE

## Tribe AESHNINI

## Genus ANAX Leach, 1815

This genus contains some of the largest of all living Odonata. The largest dragonfly of North America is an *Anax*, and the native Hawaiian *Anax strenuus* is not only the largest Hawaiian dragonfly, but is also larger than the largest North American species (*A. walsinghami* from California).

## KEY TO THE SPECIES OF ANAX FOUND IN HAWAII

1. Costal margins of wings yellowish brown, comparatively pale  
.....**junius** (Drury).
2. Costal margins of wings blackish brown, comparatively dark  
.....**strenuus** Hagen.

These two species are closely allied. Perkins (1913:clxxv) says that he has taken the males of one of these species coupled with the females of the other, and "captured three such pairs in the course of two days, when collecting in the mountains near Waialua on Oahu. Owing to the peculiar method of copulation in dragon-flies, it is not possible to say whether this truly took place or not." The nymphs are closely similar to one another.

**Anax junius** (Drury) (figs. 179, c; 181; 182; 183; 187, a-c).

*Libellula junia* Drury, 1770:112, pl. 47, fig. 5.

Warren, 1913:72, food habits. Needham and Heywood, 1929:129, fig., good general notes on habits. Kennedy, 1934:354, figs. 17, 18, 21, 23, 24. Williams, 1936:287, figs. 41, 42, 50, 51, bionomics.

The common green darner.

Kauai, Oahu, Molokai, Lanai, Maui, Hawaii.

Immigrant (?). Widespread in the Northern Hemisphere. A common pond species in the Americas (type locality: New York). This species was first recorded from

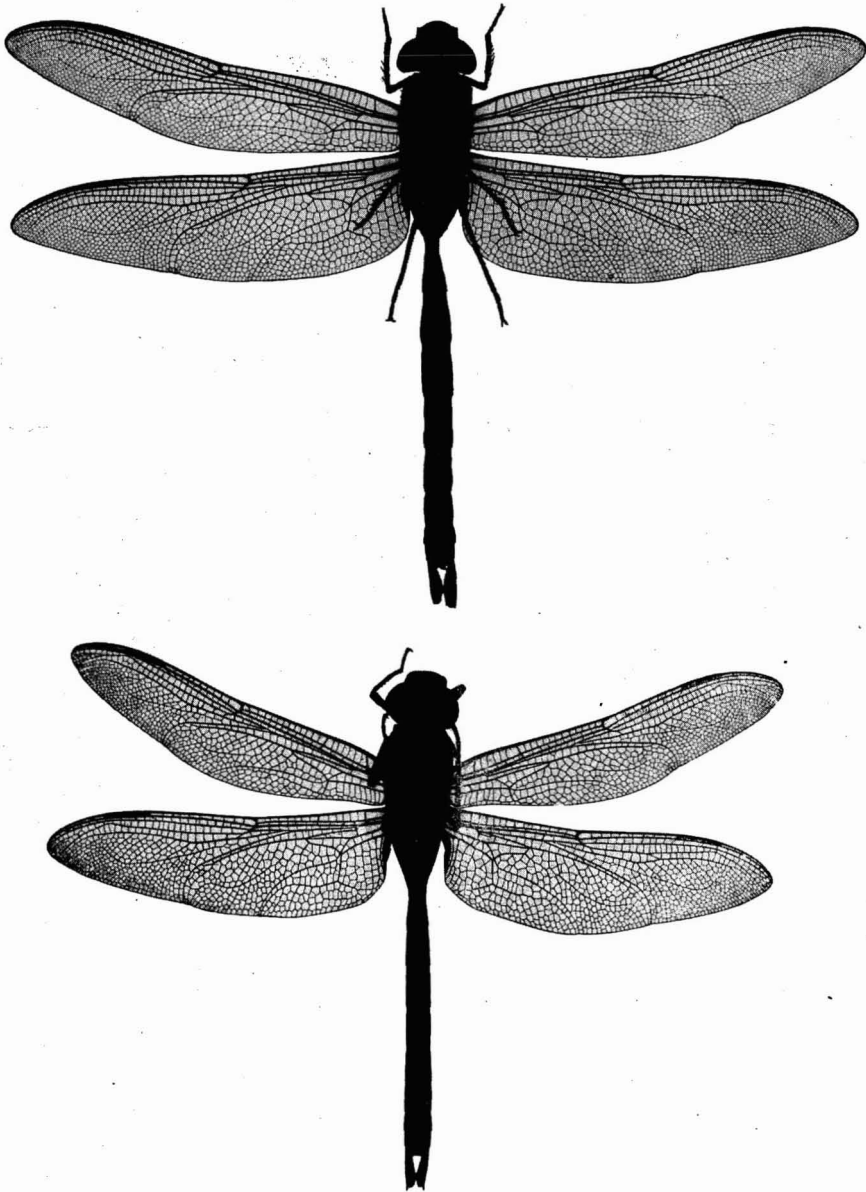


Figure 181—*Anax strenuus* Hagen, male, top, expanse 5 inches; *Anax junius* (Drury), male, bottom, expanse  $4\frac{1}{8}$  inches.

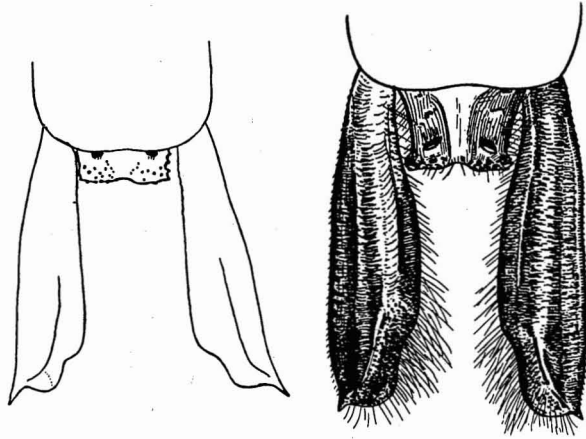


Figure 182—Dorsal views of male terminalia of *Anax junius* (Drury), left, and *Anax strenuus* Hagen, right. (After Williams, 1936.)

the islands by Hagen in 1867 (under the synonymous names of *A. severus* and *A. ocellatus*). There are no definite earlier data regarding this species in the Territory, but, because of its ability to find its way to distant parts of the world, I feel inclined to consider that perhaps it should be called "indigenous." It may have been in Hawaii for several hundred years as a natural immigrant from North America.

Parasite: although none has yet been recorded in Hawaii, it is possible that the species of *Anagrus* (?) which attacks the eggs of *Anax strenuus* may also parasitize the eggs of this dragonfly.

Predators (of naiads): fish, especially top minnows, frogs, other odonate larvae.

This species closely resembles the native *Anax strenuus*. It averages about 25 mm. less in expanse and has more yellowish wings. Williams (1936:287-288) says,

The male *junius* has the head, thorax and first segment of the abdomen green, the remainder of the abdomen being pale blue and black. The female has the greenish extending to include the second segment of the abdomen, the slender remainder being chiefly a gray brown above with green on the sides of the few terminal segments. Specimens of this dragonfly that have a wing expanse of 114 millimeters are considered large individuals though not uncommon, while those measuring 110-112 millimeters are frequently met with, and hence it would appear that these Island representatives are of a generally greater size than the same species on the mainland where Needham and Heywood (1929) give its wing expanse as 105 mm., and Seeman (1927) as 107 mm.

Williams records a specimen from Oahu which had a wing expanse of 117 mm.

This species is characteristic of the lowlands, but it is often found high in the mountains and has been seen at more than 13,000 feet. It breeds in lily ponds, reservoirs, fish ponds, swampy areas and ponds, rice fields, taro fields, etc. Williams (1936:288) notes that it breeds even in brackish water, but it thrives best "Where our lowland bodies of water contain no fish, but teem with such minute

Crustacea as Ostracoda, and with bloodworms, *Chironomus hawaiiensis*, the nymph of *Pantala flavescens* and *Megalagrion xanthomelas*, our lowland damselfly...." Warren (1915) studied the food habits of this species at Honolulu. He found that the larvae ate almost all available insects, crustaceans, molluscs and worms. Blood worms, larvae of Chironomidae, and ostracod crustaceans made up the bulk of the food taken by the nymphs examined by Warren. The larger larvae also eat tadpoles and even small fish. They may become a nuisance in fresh-water fish ponds. The adults feed on a variety of insects including other dragonflies and damselflies, Hemiptera, Lepidoptera, Coleoptera, Diptera and Hymenoptera. They are fond of honey bees.

The following notes on the life history are extracted from Williams' excellent account of the species (1936:287-290). The amber-yellow eggs are about two mm. long. They are inserted into the tissues of submerged plant stems, such as *Marsilea* and *Commelina*. The nymphal period is much shorter in Hawaii than on the mainland where it is said to last about a year, but the duration of the life cycle has not been definitely ascertained in the islands. "The nymph of *Anax junius*



Figure 183—Egg punctures of *Anax junius* (Drury) in a *Nymphaea* leaf. Photograph by F. X. Williams.)

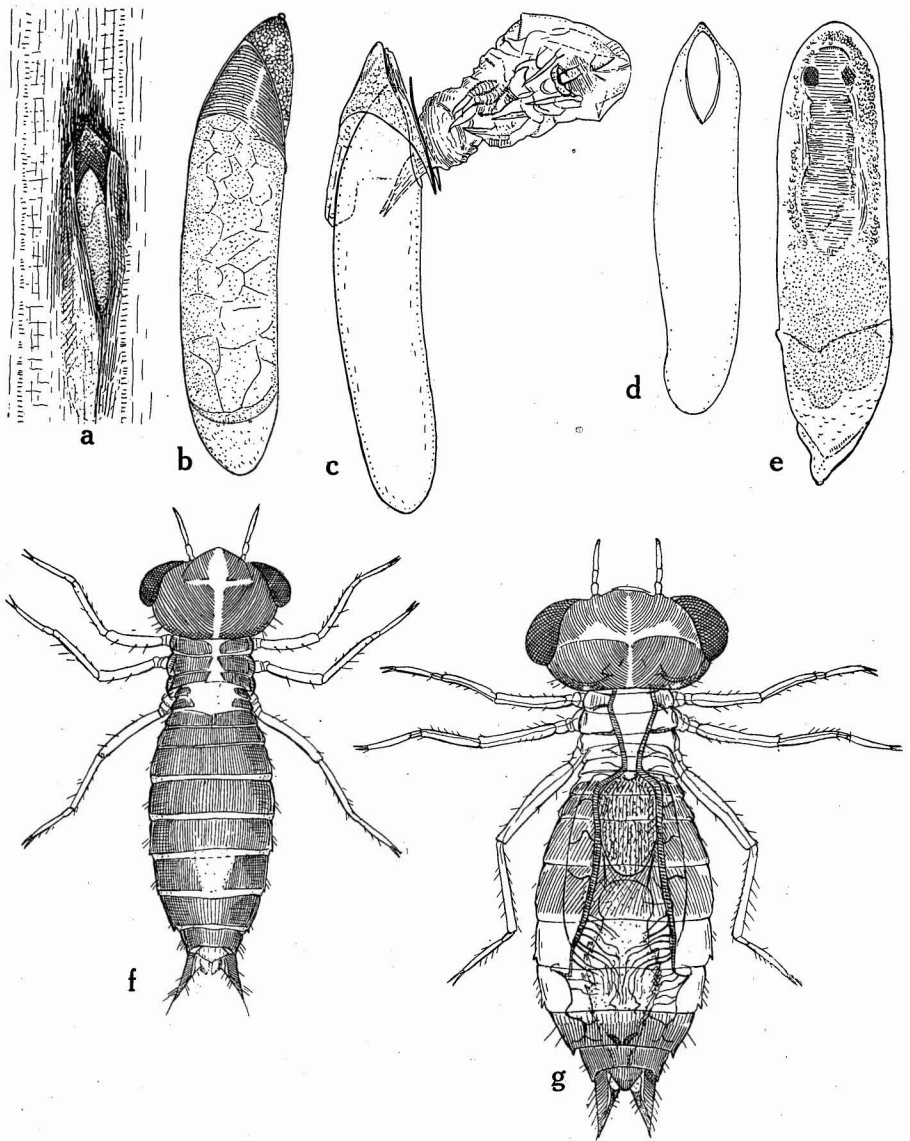


Figure 184—Developmental stages of *Anax strenuus* Hagen: a, eggs inserted in stem of *Commelina nudiflora*; b, side view of egg; c, hatched egg showing cast exuvium of pronymph protruding; d, egg shell showing exit hole; e, egg parasitized by an *Anagrus* wasp, with the parasite showing through; f, naiad (about 2.6 mm. long) after emerging from pronymphal skin 3 mm. long; g, next stage naiad (about 3 mm. long), the respiratory system is well shown here. The branchial basket lies in the pale abdominal band; the oval area just behind the thorax is the remains of the yolk in the midgut. (From original drawings for Williams, 1936.)

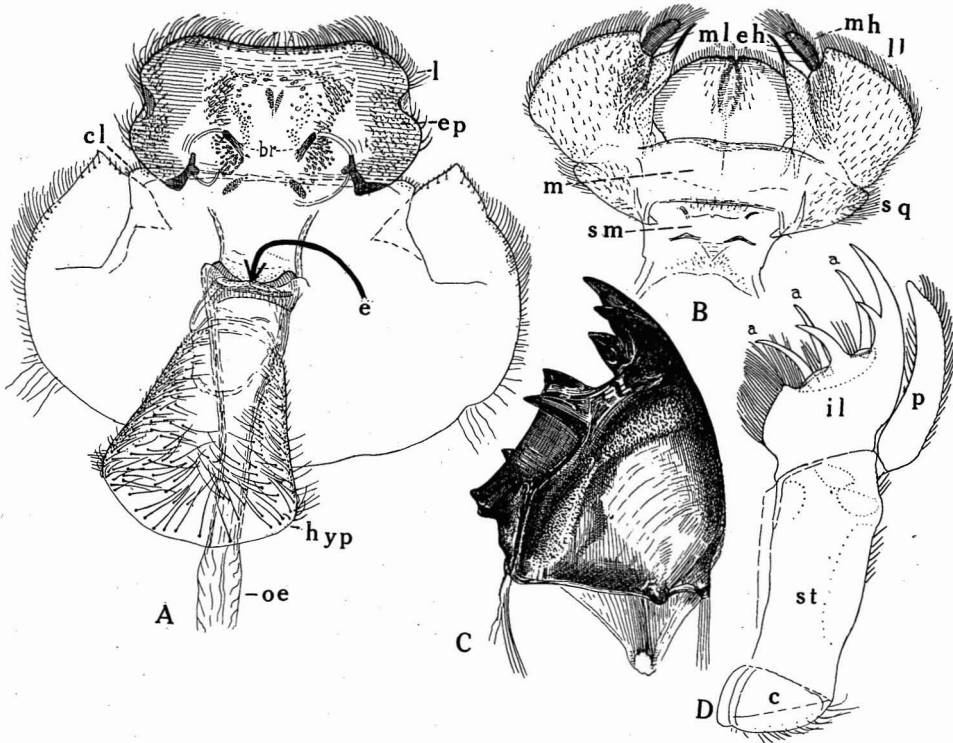


Figure 185—Morphological details of the mouth parts of the adult of *Anax strenuus* Hagen. A, underside of front part of head: l, labrum; ep, epipharynx; br, hair brushes (taste organs?); cl, lower corner of clypeus; hyp, hypopharynx, bent back to expose entrance to oesophagus (oe), at e. B, Labium: sm, submentum; m, mentum; ml, median lobe; eh, end hook; mh, movable hook; ll, lateral lobe; sq, squama. C, Right mandible. D, Maxilla: c, cardo; st, stipes; il, inner lobe; p, palpus; a, a, a, movable teeth. (From Williams' original drawings, 1936.)

undergoes many molts. In its early life it is conspicuously bicolorous...pale yellowish and dark brown; later it is brownish, more or less striped with green and is flecked with darker spots, etc. It is then somewhat more definitely patterned and less dusky than the nymph of *Anax strenuus*, that dwells in generally more shady situations in the uplands. The full grown nymph of *junius* is about 45 millimeters long. The adult issues under cover of darkness."

**Anax strenuus** Hagen (figs. 180, A; 181; 182; 184, a-g; 185, A-D; 186, a).

*Anax strenuus* Hagen, 1867:34. Blackburn, 1884:413, male. Kennedy, 1934:356, figs. 16, 22, 25, 26. Williams, 1936:274, figs. 39, 40, 43, 44-49, 52-57.

The giant Hawaiian dragonfly.

Endemic. Kauai, Oahu (type locality), Molokai, Lanai, Maui, Hawaii. (McLachlan, 1883:231, says, "The type is a female taken during the Danish 'Galathea' expedition, and is in the Copenhagen Museum.")

Parasites: an unidentified *Anagrus* (?) (Hymenoptera: Mymaridae) attacks the eggs. Dr. Williams tells me that it is evidently not *Anagrus insularis* Dozier, which attacks damselfly eggs here. Adults are occasionally seen with many mites attached to their abdomens.

Predators (of naiads): fish, *Gambusia* top minnows, gobies and others; other naiads; water beetles and their larvae.

This is not only the largest Hawaiian dragonfly, but it is also the largest Hawaiian insect. It is larger than any North American species of Odonata. Kennedy (1934:356) says, "It is so similar in color and structure to *Anax junius* which is the only other *Anax* occurring in the Islands that it is sometimes spoken of as a giant *junius*. The writer has wondered if *strenuus* might not be a tetraploid or other polyploid mutant of *junius*." The largest specimen in the Bishop Museum

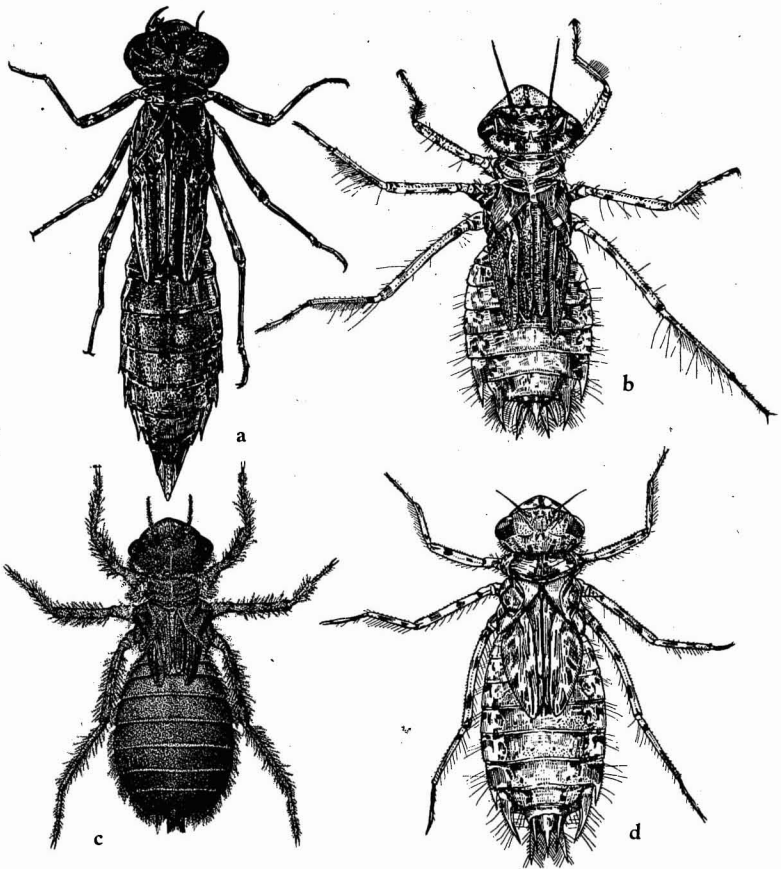


Figure 186—Dragonfly naiads: a, *Anax strenuus* Hagen, a day and a half before adult emerged (54 mm. long); b, *Tramea lacerata* Hagen, full-grown naiad, about 27 mm. long; c, *Nesogonia blackburni* (McLachlan), three-quarters grown (the fuzzy appearance is caused by a growth of *Vorticella* protozoans and bacteria among the hairs); d, *Pantala flavescens* (Fabricius), full grown, about 25 mm. long. (Rearranged from Williams' original drawings.)

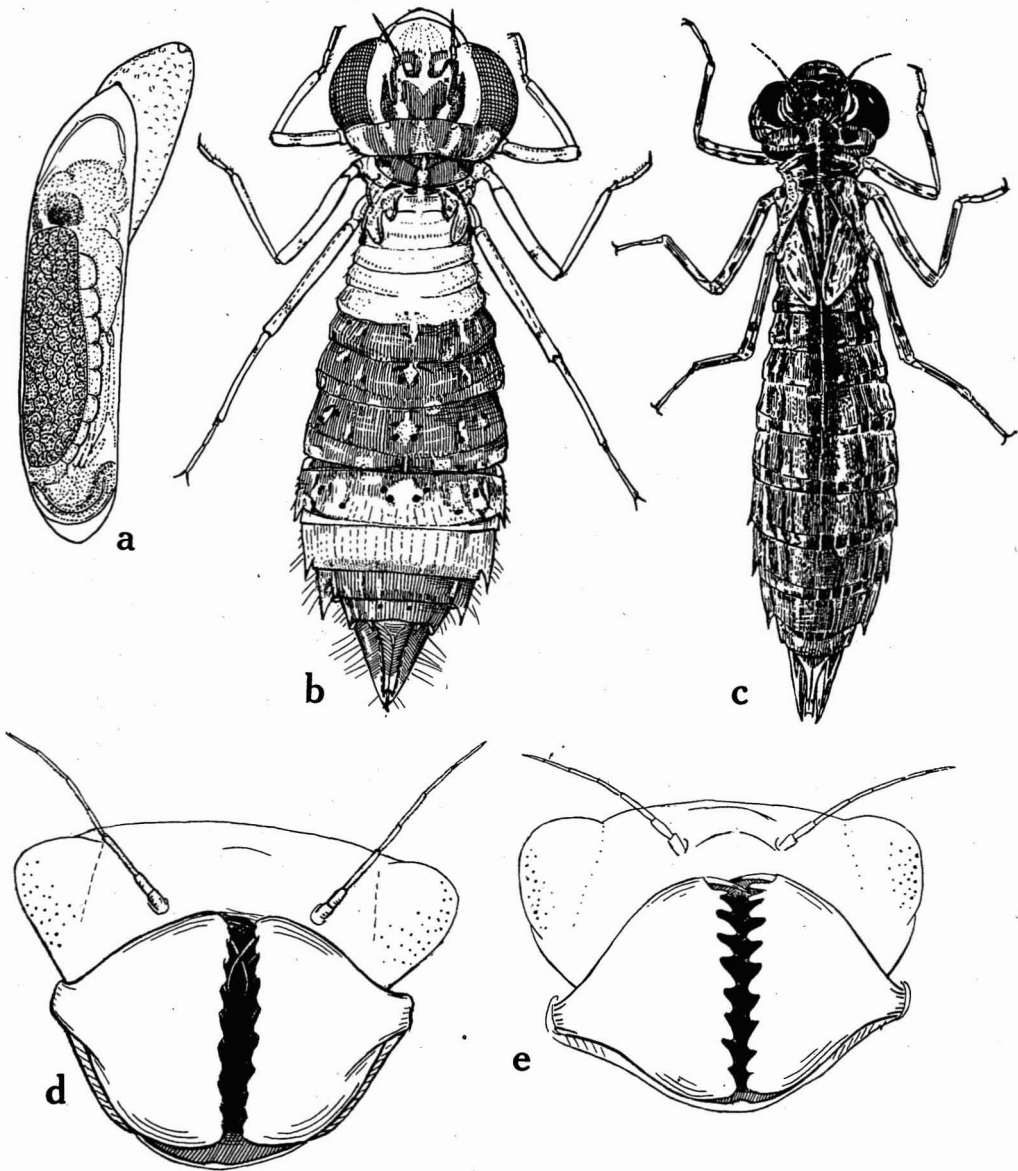


Figure 187—Features of some Odonata: a, egg of *Anax junius* (Drury); b, young naiad of same (12 mm. long); c, a naiad of the same species about three-fourths grown (35 mm. long); d, face of mature naiad of *Tramea lacerata* Hagen; e, face of *Pantala flavescens* (Fabricius). Note differences in size of teeth in lateral lobes. (From original drawings for Williams, 1936.)



has an expanse of 143 mm. Its larger size and general coloration, especially the dark fore margins of the wings, serve to distinguish it from *A. junius*. However, there are differences in the terminalia and the sternites of the first two abdominal segments of the male. These structures are subject to some variation and may be somewhat confusing, but when examined and evaluated by an experienced person, they are of definite value in separating the species. It appears to me that one of the more obvious characters of the male genitalia useful in separating *A. strenuus* from *A. junius* is the shape and size of the "inferior appendage." As indicated in the illustrations, this process is larger on *A. strenuus* and extends distinctly farther caudad than it does on *A. junius*. Its posterior margin is more deeply emarginate, and the postero-lateral angles are more strongly produced than they are in *A. junius*. In life the male may be distinguished easily from the female because of the blue color of its basal abdominal segments.

Whereas *A. junius* is more characteristic of the lowlands, *A. strenuus* is mostly a mountain species and is now only occasionally seen in the lowlands, and then only in certain places. It seems to prefer the deep canyons and cool stream pools of the mountains and breeds up to 6,000 feet or more. In the highlands of Kauai, I have seen the adults flying close to the ground over a grassy, semi-swamp, expertly flushing small moths. They eat a great variety of flying insects, including our large native damselflies.

Williams (1936:274, which reference should be consulted for details) has published an excellent account of the bionomics of this species, and the following notes are abstracted from his careful observations. The females insert their eggs, usually in double rows, into the underwater tissues of *Commelina nudiflora*, *Colocasias* spp. (taro), or other plants growing in the water or partially submerged, or even in pieces of dead, soggy vegetation lying in the water. The incubation period of the eggs, which are 2.0 to 2.25 mm. long, has not yet been accurately ascertained, but it is less than two weeks. The first instar lasts only a few seconds, and then follows a series of molts up to the last or fifteenth instar. Williams found the tarsi to be single-segmented in the first two instars, two-segmented from instar three to seven, and three-segmented from instar eight to 15. The antennae are three-segmented on hatching, four-segmented at instars three to six, five-segmented from instar seven to nine and seven-segmented from instar 10 to 15. The wing pads appear at the fifth instar. A specimen reared from egg to adult by Williams measured 2.6 mm. in length in the second instar and 53 mm. at instar 15. The naiads are brown marked with yellow in the first half of the cycle, but they become more drab in later life. The egg and larval period occupies five to six months.

The voracious larvae are known to eat a variety of organisms among which are earthworms, damselfly and dragonfly naiads (even their own relatives), fly larvae (Chironomidae, etc.), *Hydrobius* beetle larvae (Hydrophilidae), crustaceans such as shrimps, sowbugs, and amphipods, molluscs, such as *Physa*, *Lymnaea* and *Melania* ("The smaller shells may be swallowed entirely but larger ones are broken up in its jaws with quite an audible gritty crunch." Williams, 1936:281), tadpoles, small fish, and almost any available insect that happens to fall into the water.

## Superfamily LIBELLULOIDEA Selys-Longchamps, 1840

## Family LIBELLULIDAE Stephens, 1836

## Subfamily LIBELLULINAE

## The Common Skimmers

## KEY TO THE GENERA FOUND IN HAWAII

1. Adults ..... 2  
    Naiads ..... 4
- 2(1). Wings subequal in size, hind wing only slightly broader than  
       fore wing; thorax dark with conspicuous pale maculae  
       ..... **Nesogonia** Kirby.  
       Hind wings conspicuously broader than fore wings, fully  
       one-third broader at base than broadest part of fore wings;  
       thorax not so marked ..... 3
- 3(2). Vein  $R_3$  in both pairs of wings conspicuously undulated;  
       bases of hind wings with at most a yellowish tinge.....  
       ..... **Pantala** Hagen.  
       Vein  $R_3$  in both pairs of wings arcuate but not undulate;  
       bases of hind wings with a large, conspicuous, irregular,  
       dark macula ..... **Tramea** Hagen.
- 4(1). Lateral spine-like projections at posterior angles of last two  
       complete abdominal segments very short, as in figure  
       186, c ..... **Nesogonia** Kirby.  
       Postero-lateral spines on last two complete abdominal seg-  
       ments long and conspicuous, as in figure 186, b, d. .... 5
- 5(4). Teeth on lateral lobes of labium acute, strongly developed  
       ..... **Pantala** Hagen.  
       Teeth on lateral lobes of labium low, obtuse, obscure.....  
       ..... **Tramea** Hagen.

Genus **NESOGONIA** Kirby, 1898:347

Kennedy, in his paper on the "Origin of the Hawaiian Odonata Fauna" (1929: 979), says, "*Nesogonia* is so close to the holartic genus *Sympetrum* of fifty or more species that it could be put in that genus with little argument. We do not know *Sympetrum* well enough to say whether *Nesogonia* came from North America or Eurasia." If it is true that our *Nesogonia* is so close to *Sympetrum*, then I feel that much more would be gained by considering our species as a distinct and isolated species of *Sympetrum*, thus clearly indicating its obvious origin and natural affinities, than to maintain it as a monotypic genus of dubious standing. However, I cannot speak with any authority on problems concerning Odonata, and in view of the fact that specialists in the field have continued to use *Nesogonia*, it will remain for future students to consider the correct position of our species. A genus, in my opinion, cannot be maintained on the basis of geographical location alone; it must be morphologically distinct.

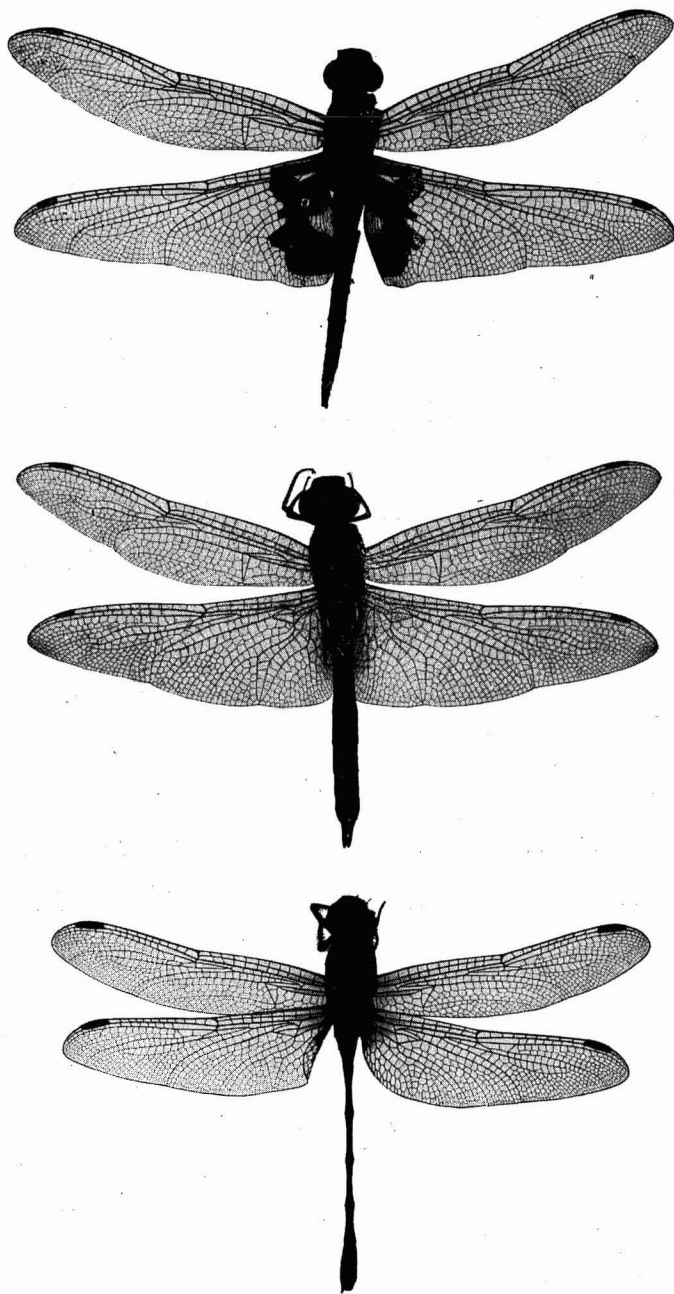


Figure 188—*Tramea lacerata* Hagen, the raggedy skimmer, female, expanse  $3\frac{3}{8}$  inches, top; *Pantala flavescens* (Fabricius), the globe skimmer, female, expanse  $3\frac{1}{2}$  inches, middle; *Nesogonia blackburni* (McLachlan), Blackburn's dragonfly, male, expanse  $3\frac{1}{4}$  inches, bottom.

**Nesogonia blackburni** (McLachlan) (figs. 179, a, b; 186, c; 188; 189, a-c; 190, a-d).

*Lepthemis blackburni* McLachlan, 1883:229; 1892:177.

*Orthetrum blackburni* (McLachlan) Kirby, 1890:36.

*Sympetrum blackburni* (McLachlan) Karsch, 1890:373.

*Nesogonia blackburni* (McLachlan) Kirby, 1898:347.

Williams, 1936:290-295, figs. 1-3, 58-65; bionomics.

Blackburn's dragonfly.

Endemic. Kauai, Oahu, Molokai, Lanai, Maui, Hawaii. No type locality was given by McLachlan.

This is a widespread, variable, native denizen of the mountains and native forests. Our smallest dragonfly, it

has an expanse of wing from somewhat less than 3 to about  $3\frac{1}{2}$  inches. The wings are for the most part nearly transparent, but the stigmal spot is reddish brown, while at their narrowed base there is a little yellowish brown and just before which, at their articulation with the thorax, there is a bit of red. The body is mainly dark, almost blackish, with some yellowish or greenish yellow dashes on the thorax, a suffusion of reddish at the bulbous base of the abdomen and a long spot of that color towards its slightly clubbed extremity. (Williams, 1936:291-292.)

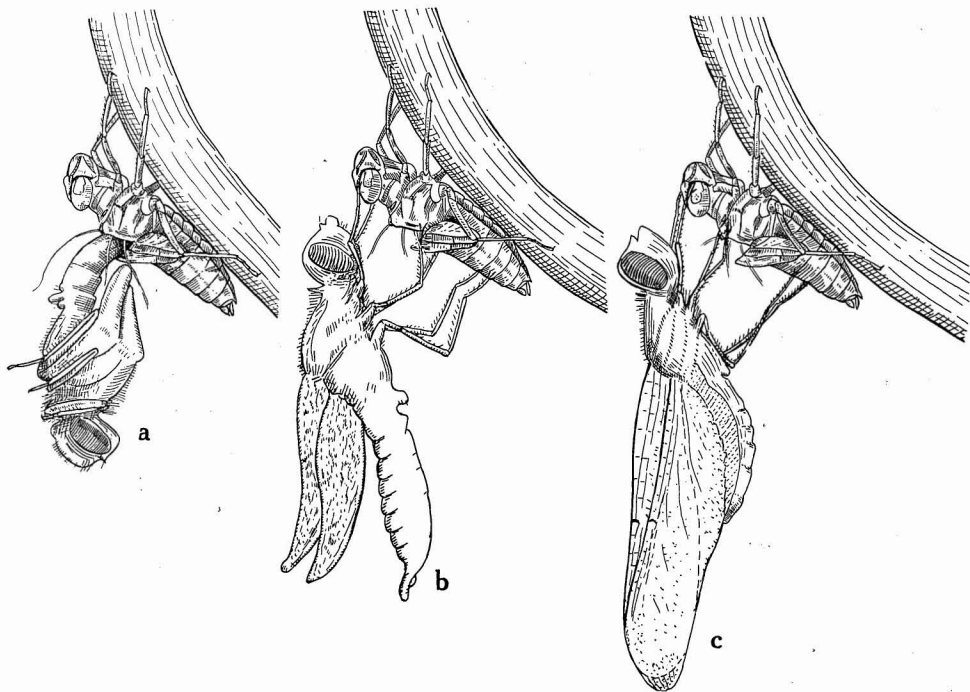


Figure 189—Sketches of stages in the emergence of an adult of *Nesogonia blackburni* (McLachlan) from its nymphal shell. b, 25 minutes after a; c, 15 minutes after b. (From drawings by Williams, 1936.)

Williams (1936:290-295) has published the only account of the bionomics of this species, from which the following details were obtained. The pale, translucent, yellow eggs measure about 0.54 mm. in length and 0.35 mm. in breadth. The fully formed eggs are washed out of the bursa copulatrix when the female, flying over a pool, puddle or stream, dips the end of her abdomen into the fresh or stagnant water. Each egg is surrounded by a clear gelatinous material. The eggs hatch in 11 to 13 days. The length of the nymphal stage and number of instars are unknown. At maturity, the nymph measures about 24 mm. in length, and "may develop a very unkempt or frowsy appearance, the nondescript brown body then harboring colonies of long-stemmed protozoans (*Vorticella*), while diatoms and clusters of sewage-like bacteria will accumulate profusely among the hairs." (Williams, 1936:294.) The naiad may readily be distinguished from the four other dragonfly naiads in the islands because the lateral spines on the abdomen are shorter than on any other species. The food habits of neither the adult nor the naiad are well known, but Williams has seen the adults feeding upon *Tanytarsus* midges and the larvae feeding upon *Culex* wrigglers. I have often seen the adults catching a variety of unidentified Diptera along mountain trails or in deep, narrow gulches.

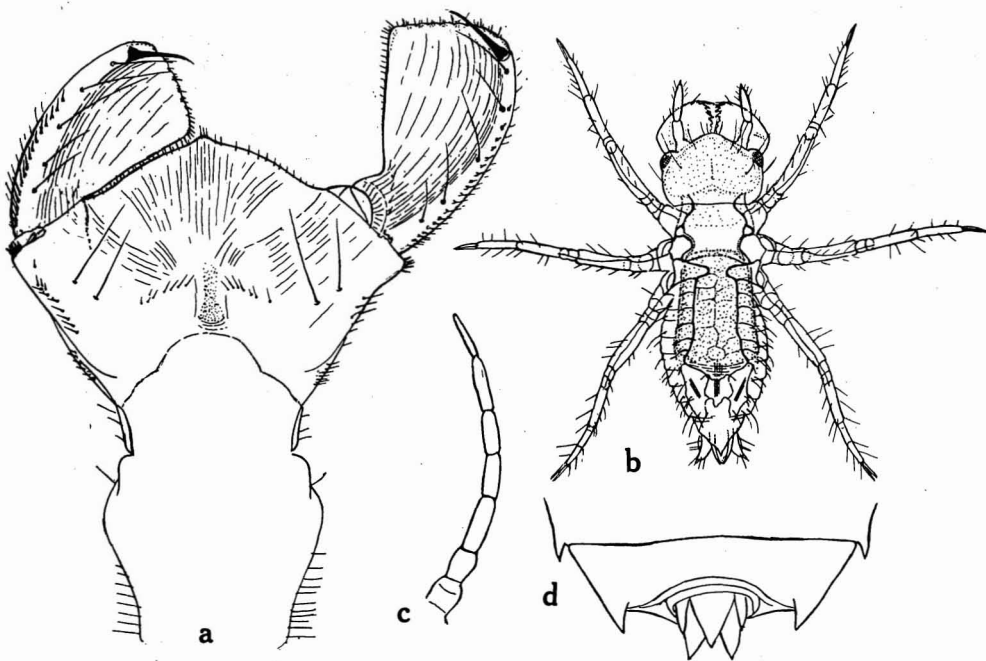


Figure 190—Details of the naiad of *Nesogonia blackburni* (McLachlan): a, inner view of labium of mature naiad; b, recently hatched naiad (tracheae and yolk mass showing); c, antenna of last-stage naiad; d, apex of abdomen of last-stage naiad. (From original drawings for Williams, 1936.)

In the box of this species in Perkins' personal collection now at the Bishop Museum there is the following note written by Dr. Perkins, which I include here for preservation: "15 unlabelled specimens (one broken) are from a gulch below Kalae, Molokai where there was a large congregation of this species, sunning themselves on dry stems a little before sundown. Many of the specimens I took were given away, and most (of the specimens seen) I did not attempt to catch. I never saw any other assemblage of this species elsewhere. R.C.L.P. II.1902." Some of Blackburn's material is also in Perkins' collection, and it bears the label "16" and "*Leptthemis Blackburni*."

Genus **PANTALA** Hagen, 1861:141

This genus is represented in Hawaii by the most widely distributed dragonfly in the world. It is:

**Pantala flavescens** (Fabricius) (figs. 186, d; 187, e; 188).

*Libellula flavescens* Fabricius, 1798:285, type from India.

*Pantala flavescens* (Fabricius) Hagen, 1861:142.

Warren, 1913:72-82; 1915:7-36. Williams, 1936:295-298, figs. 4, 67, 68, bionomics.

The globe skimmer.

Kauai, Oahu, Molokai, Lanai, Maui, Hawaii.

Immigrant. Tropicopolitan. This species is widespread in the Pacific and is found on almost every island in Polynesia. The first Hawaiian record is that by McLachlan (1883:229), who recorded specimens taken by Mathew and Blackburn (and from Beechey's voyage?). There appear to be, however, no data to indicate when the species actually first became established in Hawaii. It has been seen several hundred miles at sea.

Warren (in both 1915 papers) and Williams (1936) have published accounts of this species. It is our most common and abundant dragonfly. Although it is predominantly a lowland insect, it may be seen often in the mountains, and occasionally up to about 8,000 feet. It begins its hunting early in the morning, and on warm evenings may fly after the sun has set. It occasionally comes to light in the evening. After a rain when the subterranean termite is swarming, groups of this skimmer will frequently fly back and forth through the clouds of emerging termites, eagerly devouring them as long as there is light enough for them to see their prey. They are abundant even in the city.

The whitish to yellowish eggs are deposited by the flying female as she dips her abdomen in almost any available water, from rain water puddles to fish ponds, reservoirs and rivers. Warren collected 816 eggs from one female. The incubation period is from five to seven days. There are 11 or 12 instars which, Warren found, take 55 to 101 days for completion according to the amount of food available. A specimen fed an abundance of mosquito larvae every four or five days molted only

three times. The larvae can fast for over two weeks without ill effects. The full-grown nymphs are about 25 mm. long.

Warren examined the intestinal contents of several hundred naiads and found over one-half of the food to consist of Diptera, mostly the larvae and pupae of *Chironomus hawaiiensis*. About one-fourth of the food was the ostracod crustacean *Cypris*. Protozoa, beetles, molluscs, ants, tadpoles, Odonata nymphs, Hemiptera, fish and worms, in that order, made up the remainder of the food taken. Other organisms eaten are shrimps, *Cyclops*, leeches, millepedes, *Nereis*, nematodes, rotifers and moths, and almost any insect that happens to fall into the water. Like other dragonfly larvae, these naiads are cannibalistic. An examination of 218 adults showed that Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Odonata, Corrodentia, Thysanoptera and spiders were eaten. Small Diptera lead the list of insects eaten (about three-eighths of all food taken), followed by small beetles, small bugs, small moths and Hymenoptera.

The following note by McLachlan (1874:92) is worthy of quotation:

Of *A. Junius*, *P. flavescens*, and *T. lacerata*, Mr. Mathew [who visited Hawaii aboard H.M.S. "Repulse" in June, 1873] says that they are abundant in the Islands, and prey on the produce of what the Hawaiians call the "army worm." It is a species of *Hadena*, and occurs in countless multitudes. These large Dragon-flies used (or seemed) to follow me in numbers as I walked through the grass, darting off to the right or left of me in full chase when I disturbed a moth. They were numerous on board our ship, although we were anchored more than two miles from the shore.

#### Genus **TRAMEA** Hagen, 1861:143

A single wanderer from North America represents this genus in Hawaii.

***Tramea lacerata*** Hagen (figs. 186, b; 187, d; 188).

*Tramea lacerata* Hagen, 1861:145. Williams, 1936:298, figs. 66, 69, 70.

The raggedy skimmer.

Kauai, Oahu, Molokai, Lanai, Maui, Hawaii.

Immigrant. Described from North America. First recorded from Hawaii by McLachlan (1874:92, and 1883:229) from specimens collected by Mathew and Blackburn.

This species is found in the lowlands, usually sparingly, but occasionally in considerable numbers in certain localities. It is less common than *Pantala flavescens*, is difficult to capture and little is known of its life history in Hawaii. It lays its eggs in a manner similar to that practiced by *Pantala* and *Nesogonia*; that is, they are washed from the tip of the abdomen. The greenish yellow and brown naiads are about an inch long when full grown.

Blackburn's specimen of this species is a dermestid-eaten individual in Perkins' collection at the Bishop Museum. It has neither date nor locality labels.

The conspicuous color pattern alone will serve to distinguish this species from all the others in Hawaii.

## Suborder ZYGOPTERA Selys-Longchamps, 1854

Damselflies (Hawaiian name: "pinao-ula")

Wings held folded vertically and close together over back in repose; both pairs closely similar in size and shape, narrowed or petiolated toward base; an extra branch of media (Ms) takes place of Rs found in the Anisoptera; bridge and oblique vein absent. Head transverse; eyes button-shaped, projecting laterally at sides of head, separated by a space greater than their dorsal diameter; median lobe of labium deeply cleft. Male with four anal appendages, two superior and two inferior, the inferiors not homologous with the inferior anal appendage of the Anisoptera; penis not distinctly jointed; female with superior appendages only; ovipositor developed. Larvae with three caudal gills exposed (cercobranchiate), one medio-dorsal, two latero-ventral; rectum also used for respiration but not fitted with true tracheal gills as in Anisoptera; gizzard with eight to 16 radially symmetrical folds. (Modified from Tillyard, 1917:273.)

This suborder contains one of the most interesting and remarkable of all the endemic groups of Hawaiian insects, *Megalagrion*, and it is the only aquatic group that is developed to any extent. Also, two immigrant forms—a species of *Enallagma* and one of *Ischnura*—are now well established here.

Damselflies are much less active and are smaller, more fragile insects than dragonflies. Some of our species have a feeble sort of flight and can be captured with the hands, whereas the dragonflies are swift, agile, wary creatures, often most difficult to capture.

Native Hawaiian damselflies were much commoner and more numerous before fresh-water fishes and frogs were introduced to the islands. They will probably become rarer with the passing of the years. Some of the native species were abundant in the city of Honolulu, and it is a pity that these delicate, beautiful creatures cannot maintain themselves against the introduced predators and changed environmental conditions.

## Superfamily COENAGRIOIDEA Tillyard, 1926

Family COENAGRIIDAE Tillyard, 1926

This is the largest of the two families of Zygoptera, and it is cosmopolitan in distribution. There are no representatives of the Agrionidae found in Hawaii. This family is distinguished from the Agrionidae by the fact that it has only two instead of several ante-nodal cross-veins.

The use of Coenagriidae in place of Coenagrionidae follows Tillyard's (1926:80, footnote) explanation of the proper forms of these words:

It is unfortunate that the fine classical name *Calopteryx*, which was in general use unchallenged for three-quarters of a century, has to be discarded by the Law of Priority, the type of the Linnaean genus *Agrion* being the insect which had been known for all that time as *Calopteryx virgo* L. The new name required for the genus whose type had been known as *Agrion puella* L. was supplied by Kirby, viz *Coenagrion*, who also changed the family name to Coenagrionidae,



by analogy with the old form Agrionidae. The name *Agrion*, however, is derived from the Greek *agrias*, wild, neuter *agrion*, a wild thing, stem *agri-*, and hence the correct family names are Agriidae, Coenagriidae, Megapodagriidae, and the superfamily names Agrioidea and Coenagrioidea.

### Subfamily COENAGRIINAE Tillyard, 1926

#### KEY TO THE GENERA FOUND IN HAWAII

1. Fore wings with five or more, usually six or more, cross-veins between subnodus and the cross-vein which joins  $R_2$  at or slightly distad of origin of  $R_3$  (Occasionally specimens of *Enallagma* with five cross-veins are found, but they may be distinguished by their terminalia and general facies.) Figure 178 ..... **Megalagrion** McLachlan.  
     Fore wings with only three or four such cross-veins in our species ..... 2
2. Fore wings with three such cross-veins ..... **Ischnura** Charpentier.  
     Fore wings with four such cross-veins ..... **Enallagma** Charpentier.

Note: These character differences have been found convenient for use in separating the species of *Ischnura* and *Enallagma* found in Hawaii and are not intended for use in other localities.

#### Genus **MEGALAGRION** McLachlan

*Megalagrion* McLachlan, 1883:237. Genotype *M. blackburni*.

*Hawaiiagrion* Kennedy, 1920:86. Genotype *M. xanthomelas*.

*Kilauagrion* Kennedy, 1920:86. Genotype *M. nesiotes*.

*Oahuagrion* Kennedy, 1920:86. Genotype *M. oahuense*.

This genus is one of the most remarkable of all the Hawaiian Insecta. Its species are among the largest and most striking in the fauna. Only the dryest low-

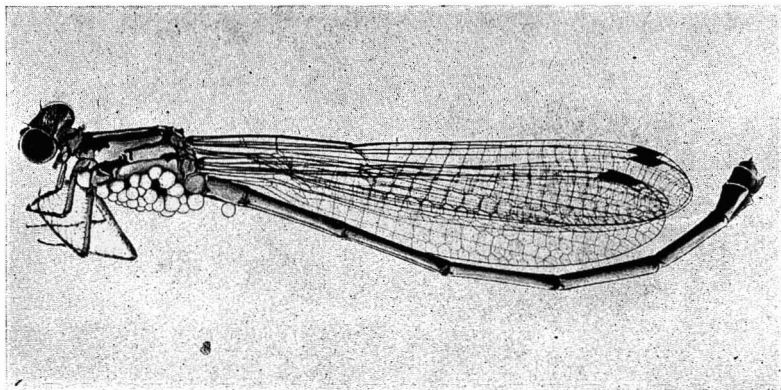


Figure 191—A female *Megalagrion* with the thorax and base of the abdomen infested with mites (Mountain View, Hawaii). (After Williams, 1936.)

lands and barren, extreme highlands are uninhabited by these net-winged creatures. Rivers and ponds have their representative species, as do wet banks and waterfalls; some species are arboreal, and at least one is truly terrestrial. The group was one of Perkins' favorites, and is one of the most extensively collected and probably the most completely known of all of the Hawaiian insects. Yet much remains to be studied and elucidated. No new species have been found since Perkins' explorations.

In this genus we find magnificently displayed the results of insular evolution and speciation. We have widespread, geographically variable species and remarkably isolated, highly specialized forms. A detailed study of the group will unfold to the student the marvels of evolution in a most dramatic way. For example, let us take *Megalagrion oahuense*. This is the most divergent of the group and is one of the most unusual of all Odonata. The nymphs of this species, unlike any other known form, have adapted themselves to a life on land. The naiads crawl about in search of their prey in the ground litter beneath dense clumps of fern. The larvae are morphologically modified for such a life. This species has taken a great step from the typical aquatic habit of the Odonata. Is it not true that this peculiar species shows us how a new order of insects could arise? Here before us we have the essence of evolution. Given time, is it not possible that this unusual damselfly whose nymphs now crawl about on damp ground could give rise to a new and distinct group of terrestrial carnivores? I believe so.



Figure 192—Mossy rain forest on Mount Kaala, Oahu, above 4,000 feet, showing some clumps of the liliaceous plant *Astelia veratroides* (in the middle) in the leaf bases of which the naiads of some of our native damselflies live. (After Williams, 1936.)

One of Perkins' earlier papers on the Hawaiian Insecta (1897:373) contains such an interesting account of the Odonata that I feel justified in quoting here his comments regarding the group.

Amongst the most important representatives of the Order of Neuroptera in the Hawaiian Islands, are the dragon-flies of the genus *Agrion*. Several species are found on all the more important islands of the group, and the range of many of them extends over several islands; wherein they differ from the greater part of the endemic insects, which are for the most part confined to a single island; or to one or two of those which lie most closely together. At the same time, when a series of examples of a species from different islands is compared, certain more or less constant differences are often observable, especially as regards size.

But the most interesting facts relate to the earlier stages or nymphs, which are aquatic and carnivorous. Excluding these dragon-flies and a few water-beetles, the insect fauna of the streams and pools is almost non-existent. The Ephemeraidae, Perlidae, and Trichoptera, usually so numerous, are entirely unrepresented in the Islands, although the mountain streams, rising at high altitudes, with their superb waterfalls, and various temperatures, appear admirably adapted for many of these. It is therefore not a little surprising to find the group of dragon-flies so well represented, and that the individuals are so numerous, being on the whole the most conspicuous of all the endemic insects. In the absence of the groups above mentioned, I believe that their main food-supply comes from without, consisting of such creatures as accidentally fall into the water. Under ordinary circumstances this is not great, but after rain, when the streams rise very quickly, food becomes abundant. When the streams, as is often the case, become nearly dry, large numbers of creatures resort to the pools that are left, for the sake of the moisture, and the numbers that come to grief is often astonishing, the whole surface being covered with the drowned and drowning.



Figure 193—A view looking along the backbone of the Koolau Mountains southeast of Konahuanui, behind Honolulu, showing, in the foreground, a *Freycinetia* plant in the leaf axils of which some of our native damselfly nymphs live. (From Williams, 1936.)

There are, however, other species the nymphs of which live under very different circumstances. These have given up their aquatic life, and live hidden at the bases of the leaves of a liliaceous plant—*Astelia veratroides*. Sometimes a little water is held by the plant around the stem, but more often there is merely a collection of damp earth and dead leaves. These nymphs would even appear to dislike the collections of water, for in wet weather they often crawl halfway up the leaves, instead of remaining at the base, where the water accumulates. They differ in some points from those which frequent the water; they are shorter and stouter, and much more sluggish, and the caudal appendages are very short and thick, differing therein greatly from some of the aquatic species, the appendages of which form beautiful tracheal gills.

On the whole they are without doubt better off as regards a food supply than the aquatic species, for there is generally abundance of animal life around them. A number of interesting beetles breed only in this plant, and minute young of molluscs and earthworms are generally abundant in the same, as well as the larvae of small moths. Moreover nymphs of various sizes often frequent a single plant, and if hard pressed for food the larger, no doubt, devour the smaller individuals.

In consequence of these habits, some of these species of dragon-flies, although their powers of flight are feeble, may often be seen in numbers in localities remote from water, and where they would not naturally be looked for.

These terrestrial nymphs are able to endure extreme drought. On one occasion when out shooting, having no more convenient receptacle, I carried a number for the greater part of the day in an envelope. In the evening, although very dry, they were still quite lively. They were then placed in a tumbler of water, where they remained on the bottom, not being able to crawl up the sides. Here they remained for a day, apparently as happily as on dry land, when they were taken out and preserved.

To this account, the reader should not fail to add the excellent review of the group given by Williams (1936:300).

When McLachlan described *Megalagrion*, he said (1883:237), "I have established this division for the reception of two of the most magnificent species of the *Légion Agrion* hitherto discovered." His main reason for erecting a new genus for *blackburni* and *oceanicum* was because some of the cells in the postcostal area were divided, thus making two rows of cellules.

Perkins did not adopt McLachlan's genus because, with his extensive collections and field observations, he was not only well aware of the great variability in wing venation but he was also familiar with the species in life. Perkins said (1913:clxxvi) that when an

extensive collection of Hawaiian species is examined, it is found that this duplication of cellules exists in all stages of development. Species that normally have a single post-costal row of cells sometimes have a number of these divided to form a double row. In some cases the post-costal area is simple on the wings of one side of the insect, partially double on the other. A similar phenomenon is also shown in the series of post-pterostigmatic cellules, where a similar complication of neurination takes place, some species always having more or less a double row, others having sometimes a single and sometimes a partially double row, or the wings on either side may be different.

*Megalagrion* is supposedly a local development from an ancestral immigrant species belonging to the widespread Indo-Pacific genus *Pseudagrion*, which extends all the way to the Marquesas Islands. Kennedy (1929:978) said that *Megalagrion* "is so closely related to the oriental genus *Pseudagrion* that the more generalized

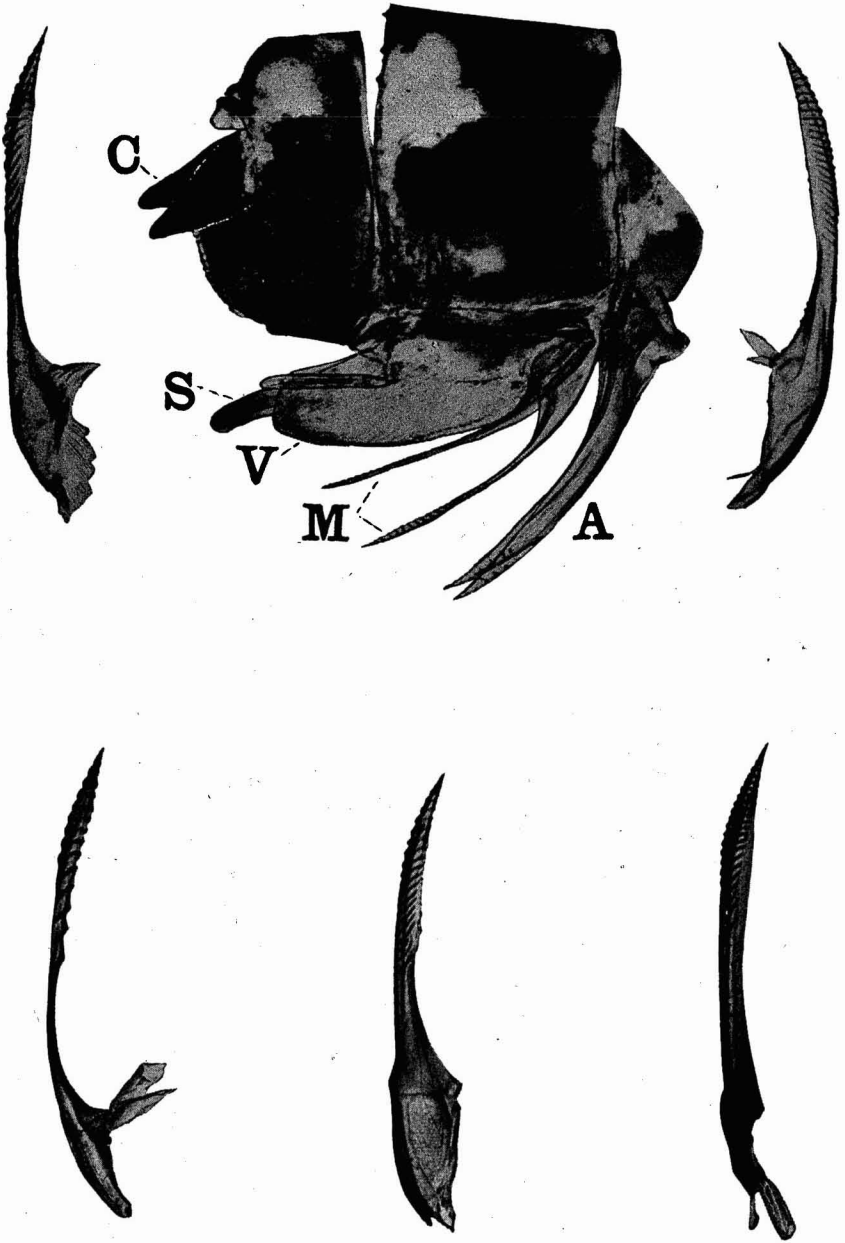


Figure 194—Ovipositors of some *Megalagrion*. Top, left, *M. hawaiiense* (McLachlan), median process; middle, *M. amaurodytum waianaeaeum* (Perkins), end of abdomen, somewhat compressed, showing components of terminalia: **A**, anterior processes; **M**, median processes; **V**, valve; **S**, style; **C**, superior anal appendages; right, *M. hawaiiense* (McLachlan), median process. Bottom, *M. koelense* (Blackburn), median process, left; *M. oceanicum* (McLachlan), median process, middle; *M. oahuense* (Blackburn), median process, right. (After Williams, 1936.)

species of *Megalagrion* could be placed in *Pseudagrion* without hesitation, if found in the Orient." Perhaps *Megalagrion* is based as much or more on geographical isolation as it is on morphological grounds. It would be most worth while to make a detailed comparison of *Megalagrion* with various species groups of *Pseudagrion* from diverse localities.

The grouping of the species of *Megalagrion* has been unsatisfactory. Perhaps if complete keys had been made the relationships of the species would have been more clearly understood. The remarkable developments of the group may be misleading, and the species must be studied in the light of the special conditions obtaining in the Hawaiian Islands. The splitting of this group of interrelated species into several genera is, I believe, neither necessary nor justified. However, it cannot be denied that there are several distinct evolutionary lines represented. Perhaps if one studied only a few of the more distinct or divergent species, he would feel that, as Odonata go, he was examining representatives of distinct genera—but that is typical of oceanic faunas. However, a review of all the species presents a different picture. The removal of *nesiotes* to a distinct, monotypic genus, for example, is ignoring its several obviously close allies and serves only to confuse the picture. The separation of the large, mostly red-bodied species associated with *blackburni* into different groups conceals their true relationships.

Unfortunately, I cannot undertake a complete and detailed revision of this remarkable group here, because I have neither the time nor the experience necessary

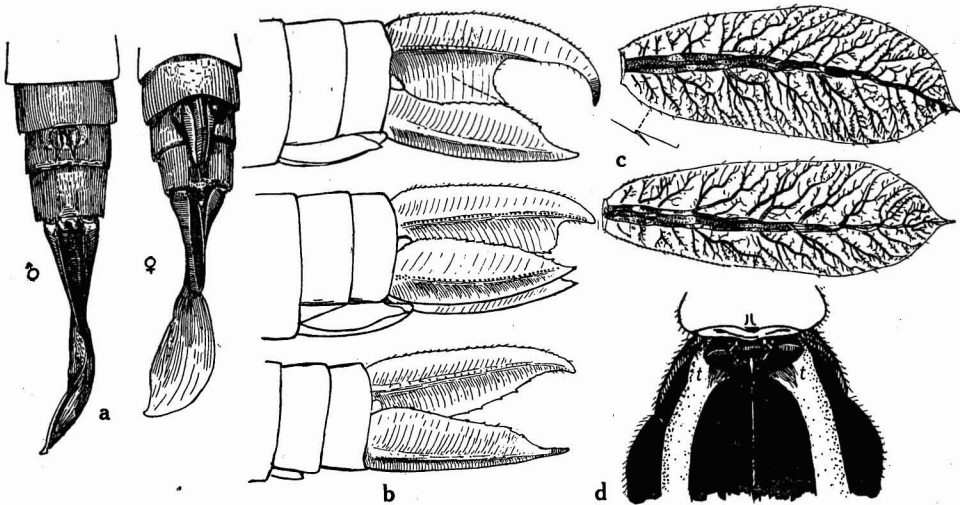


Figure 195—Details of some *Megalagrion*: a, extremities of nymphal exuviae of a male and female *M. xanthomelas* (Selys-Longchamps) to show characters differentiating the sexes in the naiad stage; b, gills of the plant-inhabiting *M. koelense* (Blackburn) to show variation (the lower figure is probably from a penultimate stage naiad); c, median and lateral gills of *M. xanthomelas* (Selys-Longchamps), a pool-inhabiting, strong-swimming form (compare these thin, densely tracheated gills with b); d, *M. oahuense* (Blackburn), dorsal view of part of thorax of a female to show the mesostigmal plate bearing tufts of hair at tt. (Rearranged from Williams' original drawings.)

for the task. However, a tentative grouping of the species as their relationships appear to me at this writing is suggested as a plan for future study by specialists. Largely on the basis of the male terminalia, I feel that the species may be divided into five major groups as follows:

Group I.—*blackburni*, *heterogamias*, *jugorum*, *molokaiense*, *oceanicum*.

Group II.—*eudytum*, *adytum*, *kauaiense*, *vagabundum*, *williamsoni*, *hawaiiense*, *nesiotes*.

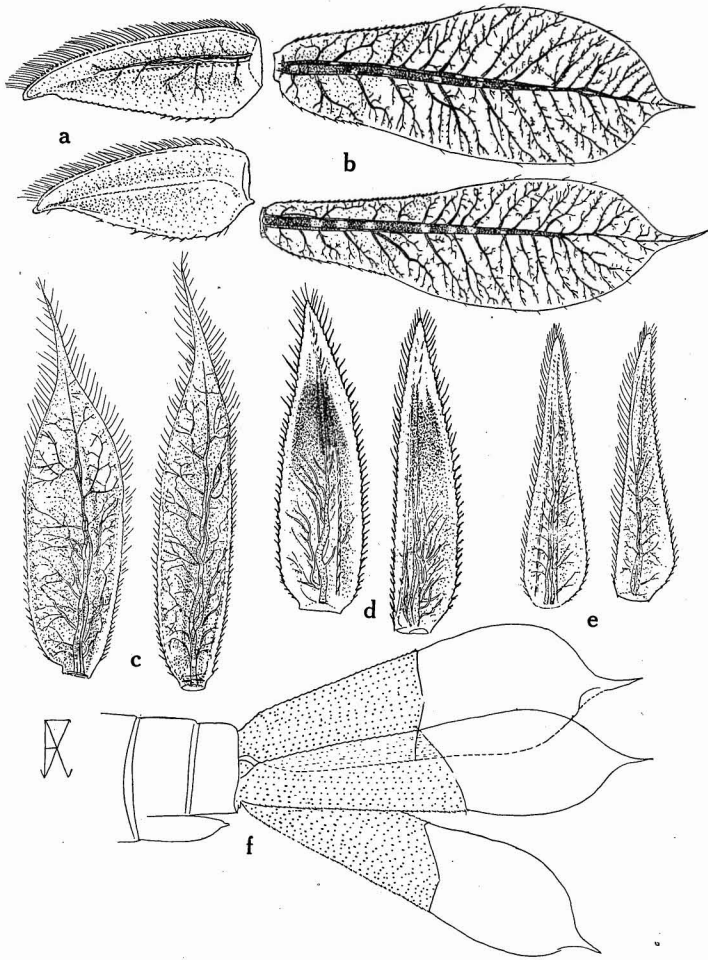


Figure 196—Gills of some *Megalagrion* species. Note the great difference between the gills of the non-swimming *M. amaurodytum waianaeae* (a) which lives at the bases of plant leaves and the actively swimming, stream-dwelling forms such as *nigrohamatum* (c). a, *M. amaurodytum waianaeae* (Perkins), median (bottom figure) and lateral caudal gills (upper figure); b, *M. leptodemas* (Perkins), median (top figure) and lateral caudal gills; c, *M. nigrohamatum nigrolineatum* (Perkins), median and lateral caudal gills; d, *M. oceanicum* McLachlan, median and lateral caudal gills; e, *M. hawaiiense* (McLachlan), median and lateral caudal gills; f, *M. leptodemas* (Perkins), lateral view of caudal gills—the stippled basal sections indicate a somewhat thicker and darker colored area. (From Williams' original figures, 1936.)



Group III.—*koelense*, *amaurodytum*, *xanthomelas*.

Group IV.—*nigrohamatum*, *calliphya*, *leptodemas*, *pacificum*, *oresitrophum*, *orobates*.

Group V.—*oahuense*.

This grouping does not necessarily indicate the relationships of each species within its group, nor are the groups here arranged in an order to indicate evolutionary trends. Certain of these groups might well be subdivided into two or more subgroups. The keys and figures will serve to characterize the groups.

The variation of features which have been used as specific or generic characters in some localities is great among the species of *Megalagrion*. The criteria used elsewhere to separate species cannot always be applied to the Hawaiian species. Many important characters are in a state of plasticity. The terminalia and genitalia are subject to a certain amount of variation. The wing venation is unstable and

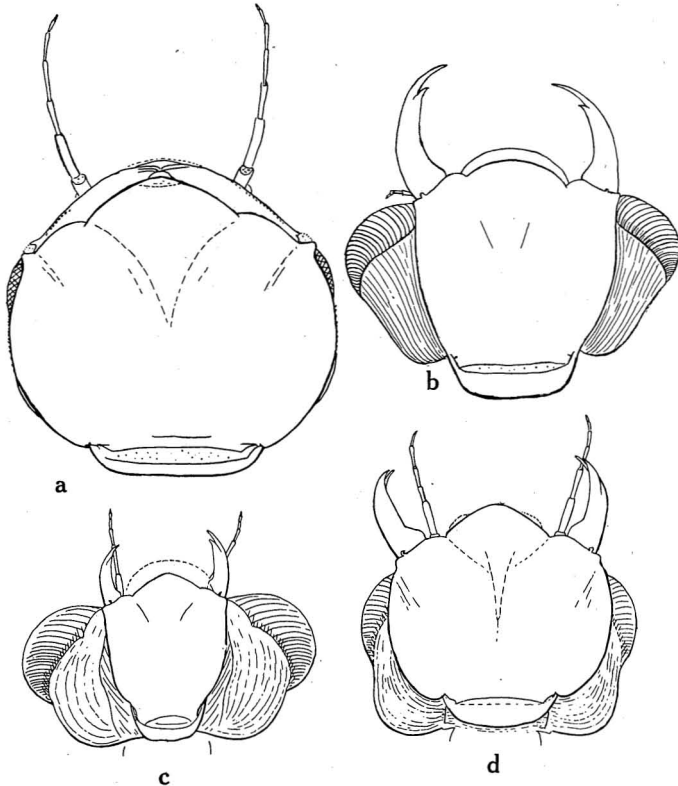


Figure 197—Undersides of heads of some *Megalagrion* nymphs: a, *M. nigrohamatum* (Blackburn)?; b, *M. amaurodytum waianacatum* (Perkins), last stage; c, *M. hawaiiense* (McLachlan), last stage; d, *M. nigrohamatum nigrolineatum* (Perkins), last stage, from a different angle than a. (From the original drawings for Williams, 1936.)



highly variable. The wings on one side of a specimen may appear to belong to a different genus from those of the opposite side. The postocular spots may be present or absent, and the color of the body may be quite variable. Some of the species vary considerably in size. Also, there are locality (ecological) differences and island differences that add to the confusion.

Tillyard (1917:103) studied the gills of one of our *Megalagrion* (*koelense*) and found them so peculiar that he assigned a special category in his scheme of classification of gills to receive that species. He called the gills "The Reduced (Non-Functional) Type." He considered that in the gills of *M. koelense* (*asteliae*) "the tracheal system is so reduced that we may reasonably claim that they no longer function as tracheal gills." *M. koelense* is one of the species whose larvae live in the leaf axils of *Freycinetia* and *Astelia* plants. Tillyard said,

Viewed externally...the gills are striking in their shortness and stoutness; indeed, they do not, even at first sight, at all suggest true caudal gills, but rather a somewhat enlarged form of *anal pyramid* such as we find in the larvae of Anisoptera. In actual shape, as revealed by cross-sections, they might be classed as Triquetro-quadrate, or intermediate between this and the Saccoid Type. The median gill is broadly diamond-shaped in section, the laterals convexly triquetral. This shape is evidently brought about by the habit of resting the median gill upon the laterals, and the laterals upon the resting-surface. The larva is, to all intents and purposes, a ground-dweller, like those of the *Calopteryginae*; but the "ground," in this case, is not the river-bed, but the débris collected in the little leaf-pools. The return to the triquetro-quadrate *outward* form is, therefore, a very interesting example of the effect of change of habit on the form of the gills.

The gills of *Megalagrion* vary considerably among the several species according to habit and habitat. The terrestrial forms have the gills much reduced and thickened, the truly aquatic, actively swimming ones have large, delicate, leaf-like gills and those that crawl have smaller, more slender gills.

Some of the species are known to be attacked by a minute hymenopterous egg parasite, *Anagrus insularis* Dozier (1936:175). Occasionally adults are captured with aquatic mites attached to them (figure 191). It is thought that the mites are distributed from one area to another by attaching themselves to the imago when it emerges from its nymphal skin and by being subsequently carried away by the adult insect.

The naiads eat a variety of food, as the discussion elsewhere outlines. The adults feed on many kinds of insects, including Diptera, Lepidoptera, Hemiptera, Homoptera, Coleoptera, etc. They take not only flying insects, but may on occasion pick insects off vegetation or off the ground. The adults of most of the species emerge from their last pupal skin during the morning hours.

The fact that the life histories of about one-half of our species are unknown is a challenge to all keen observers.

There are recognized here 22 species with five possible varieties or races. Of these 22 species, 13, so far as is known, are restricted to single islands. The insular specific species, arranged with their islands, are as follows:

Kauai: *adytum*, *eudytum*, *heterogamias*, *kauaiense*, *orobates*, *oresitrophum*, *vagabundum*, *williamsoni*.

Oahu: *leptodemas*, *oahuense*, *oceanicum*.

Molokai: *molokaiense*.

Maui: *nesiotes*.

The species found on more than one island are as follows:

*pacificum*: Kauai, Oahu, Molokai, Lanai, Maui, Hawaii.

*hawaiiense*: Oahu, Molokai, Lanai, Maui, Hawaii.

*nigrohamatum*: Oahu, Molokai, Lanai, Maui, Hawaii.

*amaurodytum*: Oahu, Molokai, Maui, Hawaii.

*calliphya*: Molokai, Lanai, Maui, Hawaii.

*koelense*: Oahu, Lanai, Maui, Hawaii.

*xanthomelas*: Oahu, Molokai, Maui, Hawaii.

*blackburni*: Molokai, Lanai, Maui.

*jugorum*: Lanai, Maui.

This list will be subject to some revision when more extensive collections are made, especially on Molokai.

This distribution reflects not only the comparative ages of the islands (Kauai is the oldest) but also the isolation of the islands (Kauai is separated from Oahu, its nearest neighbor inhabited by the genus, by a distance considerably greater than the other inter-island channels). It is significant that Hawaii, the largest, but youngest, island of the archipelago, has no species restricted to it.

The following holotypes of *Megalagrion* are in the Bishop Museum: *calverti* (Perkins), male; *koelense* (Blackburn), male and female; *leptodemas* (Perkins), male and female; *nigrohamatum* (Blackburn), male; *nigrohamatum nigrolineatum* (Perkins), male; *oahuense* (Blackburn), male (this type is badly damaged); *satelles* (Blackburn), male; *tillyardi* (Perkins), male; *williamsoni* (Perkins), male.

The variation in the wing venation of the members of this genus is so great that any key based upon venation not only would be difficult to construct but probably would be misleading and inaccurate. One might find no great difficulty in separating many species on the basis of wing venation alone if only one or a few specimens of each species were examined; but the examination of series would break down the key characters. I have been unable to devote sufficient time to this study to enable me to present here a key including the females. Regrettably, then, a key based almost entirely upon the male terminalia follows. Because a number of the species are restricted to individual islands, I have, for the sake of convenience, divided the key into three principal sections based upon distribution.

#### KEY TO THE SPECIES OF MEGALAGRION—MALES

- A. Kauai species ..... Section I.
- B. Oahu species ..... Section II.
- C. Molokai, Lanai, Maui and Hawaii species ..... Section III.

## SECTION I.—KAUAI SPECIES

1. Superior appendages of male terminalia not reaching apices of inferior appendages ..... 2
- Superior appendages of male terminalia extending beyond apices of inferiors ..... 5
- 2(1). Superior appendages, viewed from side, conspicuously bifurcate; inferiors with a preapical dorsal tooth (Note: I have no definite record of this species from Kauai, but it is placed here in case it should be found on Kauai).....  
..... *xanthomelas* (Selys-Longchamps).  
Superior appendages not bifurcate as viewed from side; inferiors not so armed..... 3
- 3(2). Superior appendages viewed from directly above, without a distinct tooth near base of inner edges.....  
..... *pacificum* (McLachlan).  
Superior appendages with a conspicuous tooth or spine on inner edges near base or with a small tooth and with apical margin of tenth tergite excised nearly to base..... 4
- 4(3). Tooth or spine on inner edge of superior appendages conspicuous, rising nearly to or to dorsum of appendage; tenth tergite emarginate only to about middle.....  
..... *oresitrophum* (Perkins).  
Spine on inner edge of superior appendage minute, not directed upward to dorsal level of appendage; tenth tergite excised nearly to base..... *orobates* (Perkins).

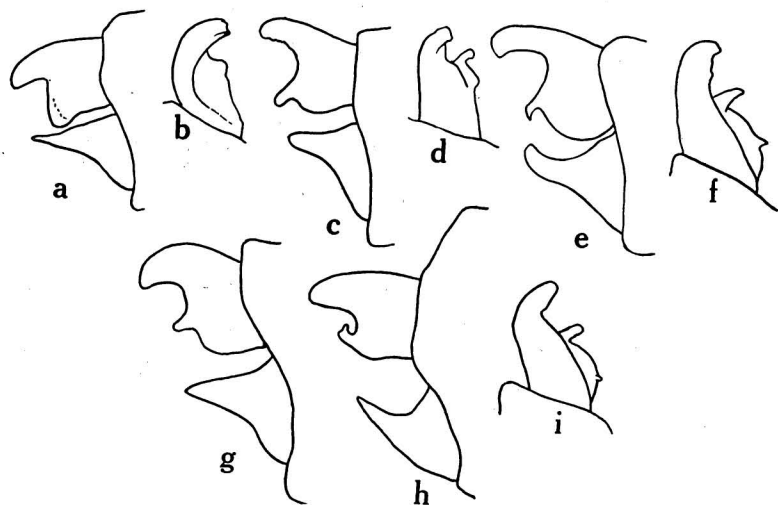


Figure 198—Details of some Kauai *Megalagrion* terminalia: a-b, *M. williamsoni* (Perkins), (a) lateral view, (b) left superior appendage from above and slightly oblique; c-d, *M. adytum* (Perkins), (c) lateral view; (d) left superior appendage from above and slightly oblique; e-f, *M. eudytum* (Perkins), (e) lateral view, (f) left superior appendage from above and slightly oblique; g-i, *M. kauaiense* (Perkins), (g) lateral view slightly oblique from beneath side, (h) as viewed directly at right angles from side, (i) left superior appendage from above and slightly oblique from right.

- 5(1). Superior appendages, as viewed from side, not bifurcate..... 6  
 Superior appendages, as viewed from side, bifurcate (lower member usually in form of a large tooth)..... 7
- 6(5). Each superior appendage, as seen from above, with lower inner edge conspicuously folded, or rolled, inward and upward to form two conspicuous tooth-like processes (usually black-tipped, and dorsal part of appendage with an apical and subapical tooth-like angulation).....  
 .....**heterogamias** (Perkins).  
 Superior appendages not so formed....**vagabundum** (Perkins).
- 7(5). Superior appendage, as viewed from above, with apical tooth on lower inner margin comparatively indistinct and rounded off, as in figure 198, a, b.....**williamsoni** (Perkins).  
 Superior appendages with apical tooth on lower inner margin, as seen from above, strong and distinctly projecting, as in figure 198, i..... 8
- 8(7). Abdomen largely red; pterostigma usually crimson; terminalia as in figure 198, g-i.....**kauaiense** (Perkins).  
 Abdomen not red, usually black; pterostigma not crimson; terminalia as in figure 198, c-d, e-f..... 9

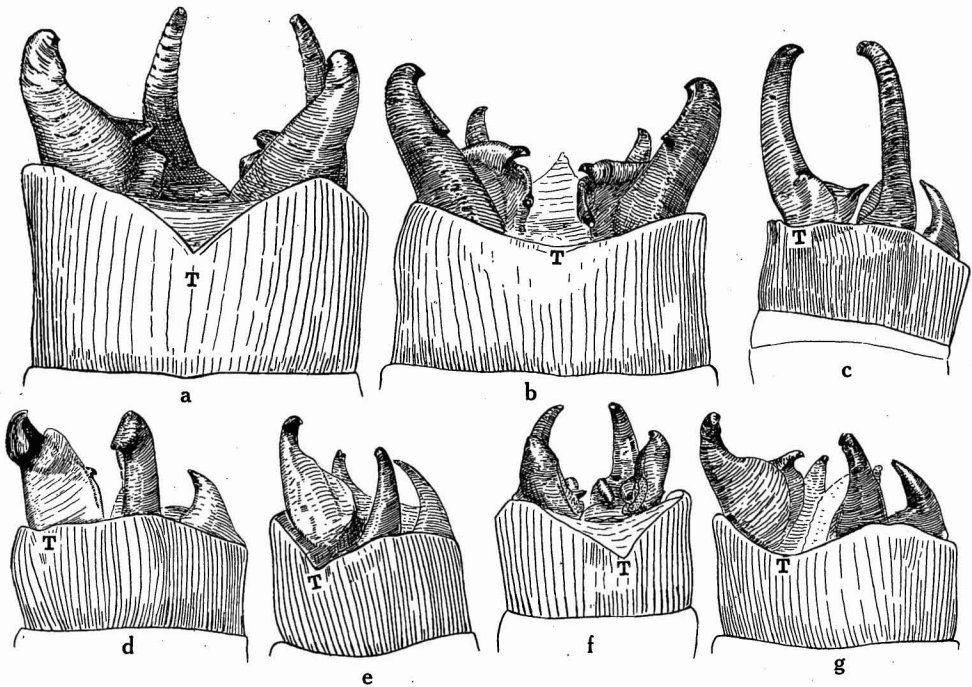


Figure 199—Male terminalia of some *Megalagrion*: a, *M. blackburni* McLachlan; b, *M. heterogamias* (Perkins); c, *M. nesiotetes* (Perkins); d, *M. molokaiense* (Perkins); e, *M. vagabundum* (Perkins); f, *M. oresitrophum* (Perkins); g, *M. jugorum* (Perkins). "T" indicates the mid-point of the tergum. (Drawings made for this text by F. X. Williams.)

- 9(8). Head, thorax and first two abdominal segments conspicuously bluish white pruinose; terminalia as in figure 198, e-f, lower inner margin of superior appendage with anterior tooth small but discernible.....**eudytum** (Perkins).  
 Not pruinose; terminalia as in figure 198, c-d, lower inner margin of superior appendage without a small anterior tooth .....**adytum** (Perkins).

## SECTION II.—OAHU SPECIES

1. Tenth tergite, viewed from side, conspicuously inclined upward and backward from base to apex; superior appendages of male terminalia turned outward, as in figure 201, f.....**oahuense** (Blackburn).  
 Tenth tergite and terminalia not so formed..... 2  
 2(1). Inferior appendages longer than superiors..... 3  
 Superior appendages as long as or distinctly longer than inferiors ..... 5  
 3(2). Superior appendages strongly bifurcate at apex; inferior appendage with a vertical tooth on dorsal margin just beyond middle.....**xanthomelas** (Selys-Longchamps).  
 Superior appendages not apically bifurcate; inferior appendage without such a tooth..... 4  
 4(3). Superior appendage usually touching or partially overlapping inferior; inferior bidentate at apex, figure 201, e.....  
 .....**nigrohamatum** (Blackburn).  
 Superior appendage distant from inferior; inferior ending in a tapering point and not apically bidentate, figure 200, c .....  
 .....**pacificum** (McLachlan).  
 5(2). Superior appendages, as viewed from side, not or hardly extending beyond inferiors, about one-half to three-fourths as long as side of tenth abdominal segment, never as long or almost as long and not bifid at apex, as in figures 200, b; 201, a..... 6  
 Superior appendages, as viewed from side, almost or quite as long as side of tenth abdominal segment, and/or bifid at apex or not bifid, as in figures 200, b; 201, a..... 7

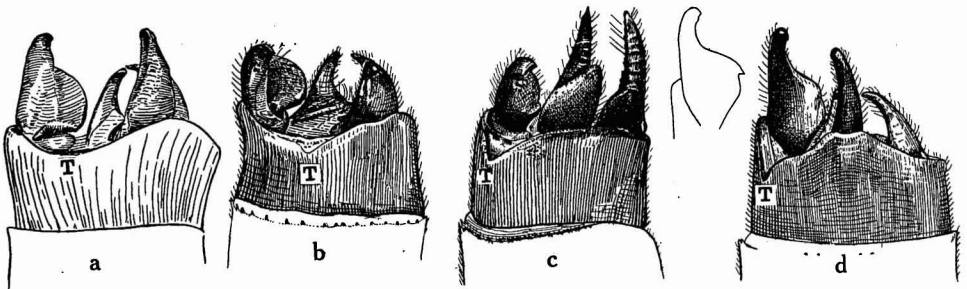


Figure 200—Male terminalia of some *Megalagrion*: a, *M. calliphya calliphya* (McLachlan); b, *M. leptodemas* (Perkins); c, *M. pacificum* (McLachlan); d, *M. hawaiiense* (McLachlan), with outline sketch of a clasper bearing a tooth. (a, drawn by F. X. Williams for this text; b-d, from original figures by Williams, 1936.)

- 6(5). Superior appendage, viewed from side very short, only about one-half as long as side of tenth abdominal segment, its height greater than its length, not attenuate, shaped as in figure 200, b; a small, slender-bodied species..... *leptodemus* (Perkins).  
 Superior appendage, viewed from side, about three-fourths as long as side of tenth abdominal segment, its length greater than its height, attenuate, shaped as in figure 201, a; a large, heavy-bodied species..... *oceanicum* McLachlan.
- 7(5). Superior appendages, viewed from directly above, each with a conspicuous, large, heavy, inwardly directed tooth on inferior margin, as in figure 201, b-c..... 8  
 Superior appendages, viewed from directly above, not from side, without such teeth, as in figure 200, d (do not confuse projecting inferior appendages with teeth)..... *hawaiiense* (McLachlan).
- 8(7). Superior appendage, viewed from above, with tooth on lower margin nearer base than apex, as in figure 201, b..... *amaurodytum* (Perkins).  
 Superior appendage, viewed from above, with tooth on lower margin nearer apex than base, as in figure 201, c..... *koelense* (Blackburn).

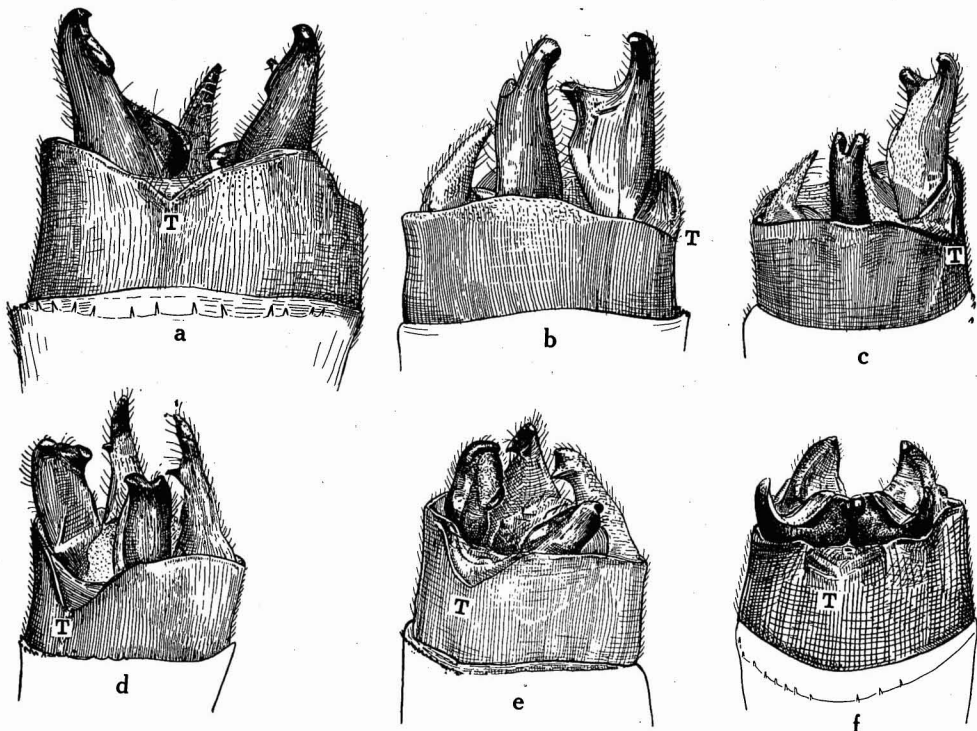


Figure 201—Male terminalia of *Megalagrion*: a, *M. oceanicum* McLachlan; b, *M. amaurodytum waianaeaeum* (Perkins); c, *M. koelense* (Blackburn); d, *M. xanthomelas* (Selys-Longchamps); e, *M. nigrohamatum nigrohamatum* (Blackburn); f, *M. oahuense* (Blackburn). "T" marks the mid-point of the tergum. (From the original figures for Williams, 1936.)

## SECTION III.—SPECIES FROM MOLOKAI, LANAI, MAUI OR HAWAII

1. Superior appendages of male terminalia, as viewed from side, not extending beyond apices of inferiors..... 2  
 Superiors extending beyond apices of inferiors, usually conspicuously so ..... 5
- 2(1). A very large, heavy-bodied, largely red-abdomened species (expanse across fore wings 60 to about 80 mm.); fore wings with about six cross-veins between media and cubitus between quadrilateral cell and cross-vein extending to subnode ..... **blackburni** McLachlan.  
 Small or medium-sized species whose fore wings have only two or three such cross-veins, less than 60 mm. in expanse across fore wings..... 3
- 3(2). Superior appendages strongly bifurcate at apex; inferior appendages each with a vertical tooth on dorsal margin just beyond middle.....**xanthomelas** (Selys-Longchamps).  
 Superior appendages not apically bifurcate; inferior appendages without such a tooth..... 4
- 4(3). Each superior appendage distant from its inferior appendage; inferiors each ending in a tapering point and not apically bidentate (fig. 200, c).....**pacificum** (McLachlan).  
 Each superior appendage touching or partially overlapping its inferior; inferior bidentate at apex (fig. 201, e).....  
 .....**nigrohamatum** (Blackburn). 4
- 5(1). Superior appendages almost twice as long as length of tenth abdominal segment as seen from side (fig. 199, c).....  
 .....**nesiotes** (Perkins).  
 Superior appendages shorter or hardly longer than side of tenth abdominal segment ..... 6
- 6(5). Post-pterostigmatic cells at least in part subdivided by longitudinal connectives between cross-veins, as in figures 207, *jugorum*, and 208, *molokaiense*; pterostigma normally covering two cells; large, usually reddish-bodied species over 60 mm. in fore wing expanse and length of body over 50 mm. .... 7  
 Post-pterostigmatic cells not so subdivided; pterostigma normally covering one cell; small or medium-sized species under 60 mm. in fore wing expanse and body usually less than 50 mm. long..... 8
- 7(6). Maui and Lanai species; male terminalia as in figure 199, g .....**jugorum** (Perkins).  
 Molokai species; male terminalia as in figure 199, d.....  
 .....**molokaiense** (Perkins).
- 8(6). Superior appendages, as viewed from directly above, with lower margin produced in a conspicuous and strongly developed, internally projecting, tooth-like process, thus making each appendage appear apically bifid when viewed from side or from beneath ..... 9

- Superior appendages without such a process and not appearing apically bifid .....10
- 9(8). Superior appendages, when viewed from above, each with tooth on lower margin nearer base than apex, as in figure 201, b. ....**amaurodytum** (Perkins).  
 Superior appendages, viewed from above, each with tooth on lower margin nearer apex than base, as in figure 201, c ..... **koelense** (Blackburn).
- 10(8). Superior appendage, as viewed from above, with a dorsally directed, tooth-like process, usually at least in part polished black, near base on inner face. .... **calliphya** (Perkins).  
 Superior appendages without a trace of such a tooth-like process (as seen from above, not from side).....  
 ..... **hawaiiense** (McLachlan).

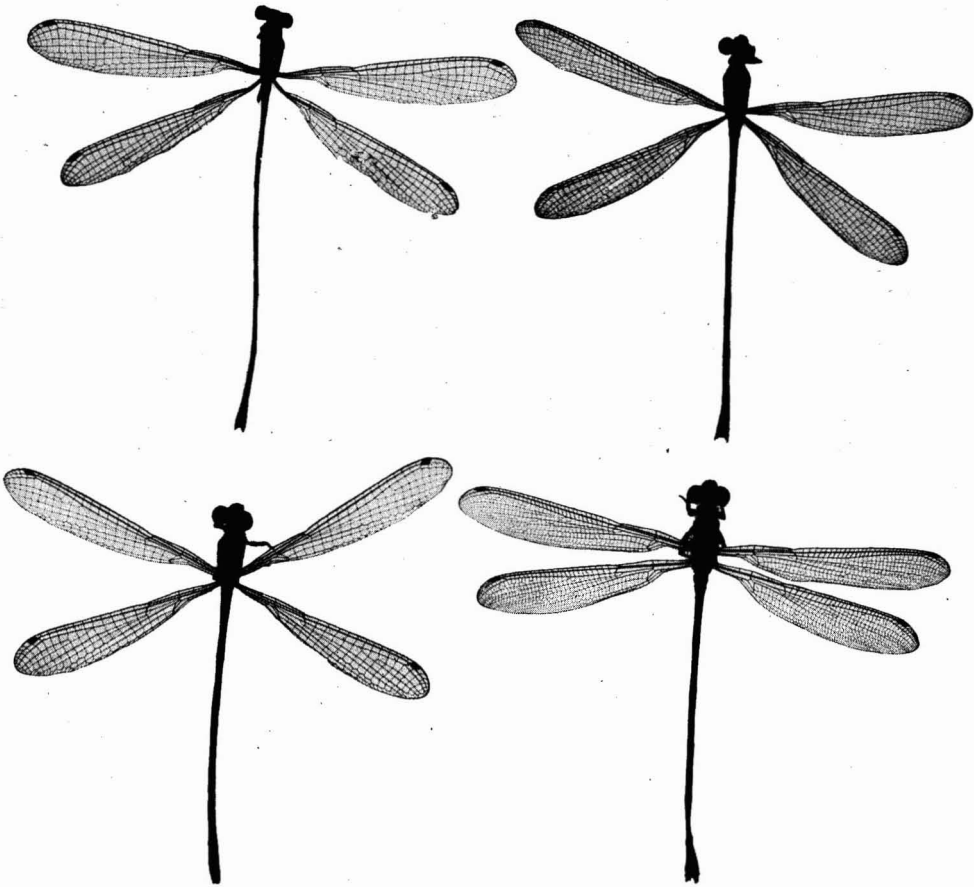


Figure 202—*Megalagrion*. Top: *M. adytum* (Perkins), left; *M. amaurodytum amaurodytum* (Perkins), right. Bottom: *M. amaurodytum peles* (Perkins), left; *M. blackburni* McLachlan, right. (Not to same scale.)



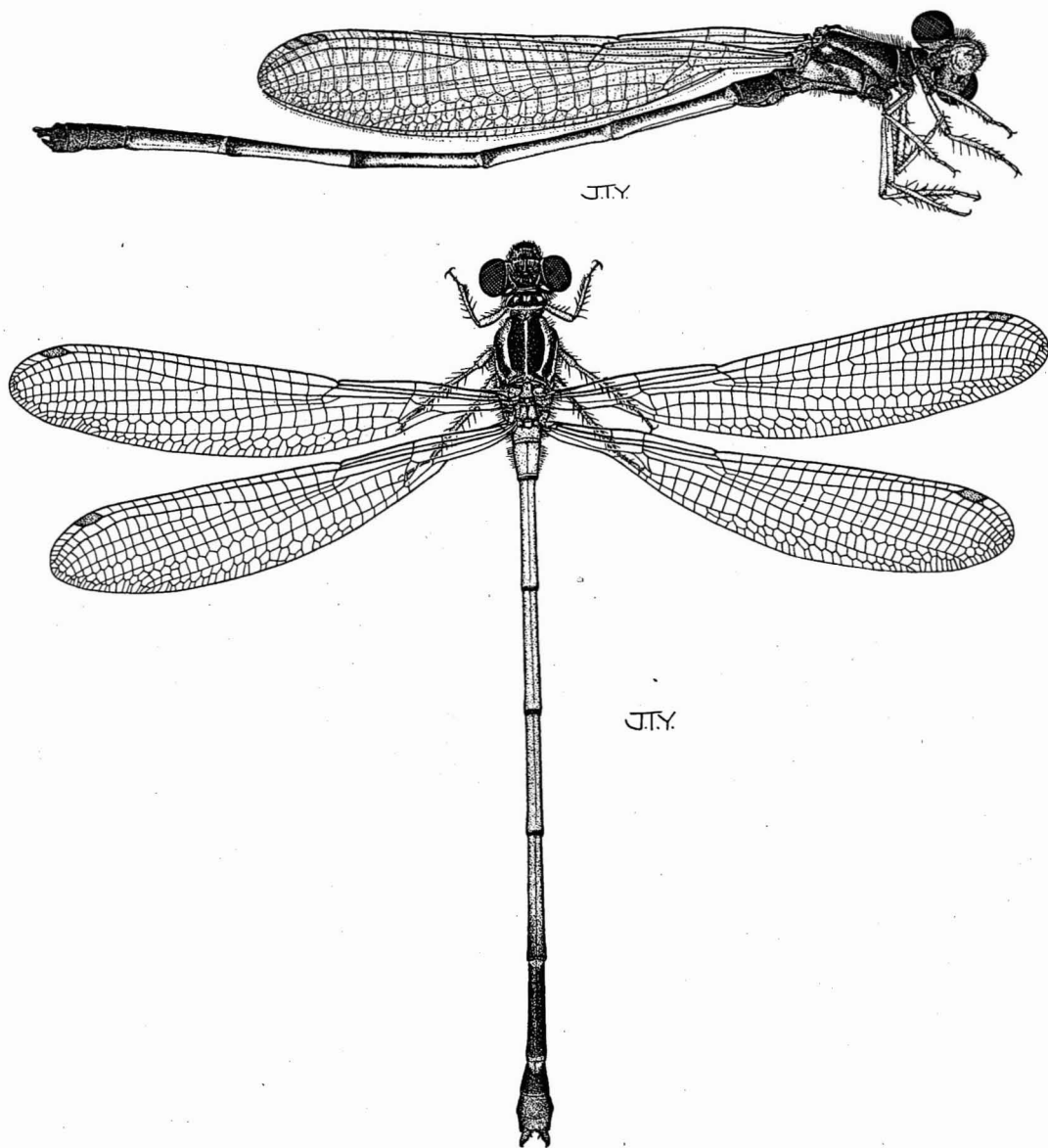


Figure 203—Top, *Megalagrion amaurodytium waianaeum* (Perkins), male, body length, 42 mm., from nymphal shell illustrated in fig. 211. Bottom, *M. oceanicum* McLachlan, male, wing expanse, 58 mm. (From Williams' original figures, 1936.)

**Megalagrion adytum** (Perkins) (figs. 198, c-d; 202).*Agrion adytum* Perkins, 1899:69.*Agrion adytum* variety *tillyardi* Perkins, 1910:695.*Megalagrion adytum* (Perkins) Kennedy, 1917:11.

Endemic. Kauai (type locality: 4,000 feet; type locality of *tillyardi*: "near Lihue on a mountain stream.").

This species is allied to *eudytum* (Perkins); nothing is known regarding its habits.

The type of the "variety" *tillyardi* is in the Bishop Museum and has been labeled by Perkins as a synonym of *adytum*.

**Megalagrion amaurodytum amaurodytum** (Perkins) (fig. 202).

*Agrion amaurodytum* Perkins, 1899:66, pl. 5, figs. 7, 7a. (NOTE: These figures do not apply to *koelense* as stated in *Fauna Hawaiiensis*. See Perkins, 1912:180, for explanation.)

*Megalagrion amaurodytum amaurodytum* (Perkins) Kennedy, 1917:11.

Endemic. Molokai, Maui (no definite type locality cited by Perkins).

Williams (1936:332) found this form breeding in *Astelia* plants above 2,000 feet on Molokai. The mature nymphs attain a length of slightly more than 20 mm.

Perkins (1899:67) described, but did not name, a "Larger and darker var. from high ridges of W. Maui Mts. (4000 ft.)."

This species is closely allied to *koelense* (see discussion under that species). It is a variable species and "may be an entirely blackish insect, with much bluish white pruinosity on the head, thorax and the base of the abdomen, or it may be of a more metallic black with conspicuous thoracic pale markings, or in addition to much pale ornamentation the abdomen may be largely red." (Perkins, 1913: clxxvi.) Further studies of large series of specimens from many localities are essential before the status of the forms of this species can be properly understood.

**Megalagrion amaurodytum fallax** (Perkins).*Agrion amaurodytum* variety *fallax* Perkins, 1899:67.

Endemic. Hawaii (no specific type locality given by Perkins).

Schmidt (1938:326) lists this as an aberration and a synonym of *M. amaurodytum* *peles*, but he gives no substantiating data. Perkins' original notes (1899:67-68) read,

Where the typical form abounds an extraordinary variety is sometimes found. This has the abdomen more or less red in both sexes, the third segment generally almost entirely so; the legs are almost wholly pale. The post-ocular spots are red or yellow, large and connected (or almost so) by a red or yellow line. The prothorax is much spotted and the longitudinal lateral lines of the dorsum of the thorax are broad and distinct, while the pale marks which border the eyes inwardly are connected by a transverse band just behind the posterior margin of the clypeus.

**Megalagrion amaurodytum peles** (Perkins) (fig. 202).

*Agrion amaurodytum* race *peles* Perkins, 1899:67.

*Megalagrion amaurodytum* race *peles* (Perkins) Kennedy, 1917:11, figs. 7, 8, penis.

Endemic. Hawaii (type locality not specified by Perkins, but between 2,000 and 4,000 feet in elevation, probably between Olaa and Kilauea).

Perkins refers to this as a dwarf form of the species; it has only three cellules between the quadrilateral and nodus.

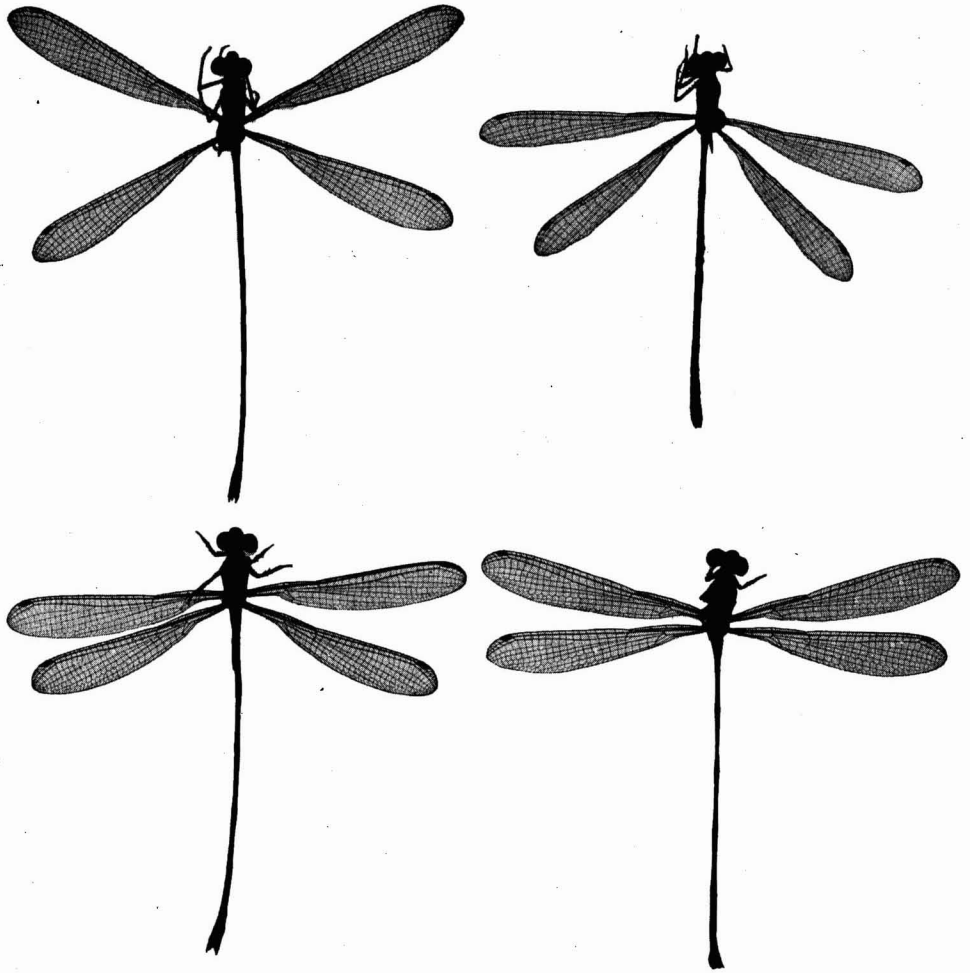


Figure 204—*Megalagrion*. Top: *M. calliphya calliphya* (McLachlan), left; *M. calliphya microdemas* (Perkins), right. Bottom: *M. eudytum* (Perkins), left; *M. hawaiiense* (McLachlan), right. (Not to same scale.)

**Megalagrion amaurodytum waianaeaeum** (Perkins) (figs. 194; 196, a; 197, b; 201, b; 203; 211).

*Agrion amaurodytum* race *Waianaeaeum* Perkins, 1899:67.

*Megalagrion amaurodytum waianaeaeum*, misspelling by Schmidt, 1938:326.

Williams, 1936:332, pl. 14, fig. 87, gills.

Endemic. Oahu (type locality: Waianae Mountains, 2,000 to 3,000 feet).

Williams (1936:332) has studied the larvae and habits of this form. The naiads live in the leaf axils of *Astelia* and *Freycinetia* on the higher peaks of the Waianae Mountains. The eggs are inserted in the leaf tissue (in the upper side of the mid-ribs in *Freycinetia*). Their habit of living in the confined leaf axils, where the amount of available water is small, appears to have resulted in the loss of the ability to swim. Williams placed some nymphs in water and found that they were definitely ill at ease and unaccustomed to being submerged and appeared unable to swim. He says that the "mature nymph is in general brownish or slightly greenish brown; wood brown on the back and dark along the sides of the abdomen."

**Megalagrion blackburni** McLachlan (figs. 199, a; 202).

*Megalagrion Blackburni* McLachlan, 1883:238; 1892:178. Genotype.

*Agrion blackburni* (McLachlan) Perkins, 1899:76, pl. 5, figs. 15, 15a.

Kennedy, 1917:11, figs. 17, 18, penis.

Endemic. Molokai, Lanai, Maui (type locality: "At the head of Wailuku Valley"), Hawaii.

The nymphal stage of this species is included with that of *oceanicum* by Williams in his key to the nymphs (1936:348); it lives in streams and on wet banks.

The only specimen in Blackburn's collection acquired by Perkins and now in the Bishop Museum was received by Perkins in fragmentary condition. It lacks head and abdomen, but the wings are intact.

This species belongs to the *heterogamias*, *oceanicum*, *jugorum*, *molokaiense* complex of large, heavy-bodied species.

**Megalagrion calliphya calliphya** (McLachlan) (figs. 200, a; 204).

*Agrion* (?) *calliphya* McLachlan, 1883:236.

*Coenagrion Calliphya* (McLachlan) Kirby, 1890:151.

*Agrion calliphya* McLachlan, Perkins, 1899:71, pl. 5, figs. 9, 9a; 1913:clxxvii, figs. 3a, 3b.

*Agrion* ? *satelles* Blackburn, 1884:414, type from Haleakala, Maui, 4,000 feet.

*Coenagrion* ? *Satelles* (Blackburn) Kirby, 1890:151.

*Agrion satelles* Blackburn, Perkins, 1899:74.

*Megalagrion calliphya calliphya* (McLachlan) Kennedy, 1917:11, figs. 9, 10, penis.

*Hawaiiagrion calliphya* (McLachlan) Kennedy, 1920:86.

There is confusion regarding the synonymy involved here. Perkins (1899:74) said, "I cannot identify this species with any known to me. A large form of *Agrion deceptor* and a similar one of *A. calliphya* are common in the locality." The locality mentioned is Haleakala, Maui, 4,000 feet. Some years later, Perkins acquired Blackburn's collection; and two of Blackburn's examples of *satelles*, including the type, are now in Perkins' collection at the Bishop Museum. A note placed by Perkins with these examples reads, "Blackburn's type of *A. satelles*=*calliphya* McL. of F[auna] H[awaiiensis]." Also, on the specimen considered the type, Perkins attached the following note: "This is what I call *A. calliphya* in F. H." These notes would appear to indicate that *satelles* is a synonym of *calliphya*. However, the matter is not entirely clear to me, for Perkins wrote to F. X. Williams (letter of June 14, 1935) that "The status of *calliphya* McL. was somewhat uncertain, since, if I remember rightly, the specimen supposed to be this in Blackburn's coll. was not what I called *calliphya*, but what I considered a large form of *deceptor*. I was therefore very anxious that M. L.'s [McLachlan] type should be examined. It is quite likely that the specimen retained by Bl. may have been different from the one he sent McLachlan, since he (Blackburn) when he sent them to M. L. thought *deceptor* and *oceanicum* to be one species." Blackburn's example of what he called *calliphya* is in Perkins' collection at the Bishop Museum, and it bears the following label, written by Perkins: "*A. calliphya* sec. T. Blackburn. Really *A. deceptor*." As I understand it, Blackburn described *calliphya* as *satelles*, because he had incorrectly identified specimens of *deceptor* as *calliphya* and really compared his *satelles* with *deceptor*. In any case, Blackburn's type of *satelles* belongs to what is here called *calliphya* and not to *deceptor*.

Endemic. Molokai, Lanai (type locality: "about 2,000 feet"), Maui.  
Nothing is known about the early stages of this form.

**Megalagrion calliphya microdemas** (Perkins) (fig. 204).

*Agrion calliphya* race *microdemas* Perkins, 1899:71; 1913:clxxvii, figs. 4a, 4b.

*Megalagrion calliphya microdemas* (Perkins) Kennedy, 1917:12, figs. 11, 12, penis.

*Hawaiiagrion calliphya microdemas* (Perkins) Kennedy, 1920:86.

Endemic. Hawaii (no definite type locality given by Perkins, but it is known to occur around Kilauea).

Nothing is known of the bionomics of this dwarf race.

**Megalagrion eudytum** (Perkins) (figs. 198, e-f; 204).

*Agrion eudytum* Perkins, 1899:68.

*Megalagrion eudytum* (Perkins) Kennedy, 1917:12, figs. 13, 14, penis.

Endemic. Kauai (type locality: "about 1,000 ft.").

This species is recorded in the *Fauna Hawaiiensis* from a single pair, but there

are seven additional specimens in Perkins' collection at the Bishop Museum which are labeled "Kauai, Lihue, 1000 ft." Nothing is known about its habits or early stages.

**Megalagrion hawaiiense** (McLachlan) (figs. 194; 196, e; 197, c; 200, d; 204; 205, a-r; 206).

*Agrion* (?) *hawaiiense* McLachlan, 1883:232.

*Coenagrion Hawaiiense* (McLachlan) Kirby, 1890:151.

*Agrion hawaiiense* McLachlan, Perkins, 1899:64.

*Megalagrion hawaiiense* (McLachlan) Kennedy, 1917:13, figs. 35-36, penis.

*Agrion calverti* Perkins, 1910:694 (type from near Honolulu, 1,200 feet, in Bishop Museum).

*Agrion* (?) *deceptor* McLachlan, 1883:235.

*Coenagrion Deceptor* (McLachlan) Kirby, 1890:151.

*Agrion deceptor* McLachlan, Perkins, 1899:74; 1913:clxxvii, fig. 2.

*Megalagrion deceptor* (McLachlan) Kennedy, 1917:13, figs. 15, 16 (not this species?).

*Hawaiiagrion deceptor* (McLachlan) Kennedy, 1920:86. New synonym.

Kennedy, 1917:12, figs. 15, 16, illustrates the penis of an atypical *deceptor*, or another species. See Calvert's footnote on page 13 of Kennedy's paper.

Endemic. Oahu (type locality: "at no elevation above the sea"), Molokai, Lanai, Maui, Hawaii. (Kennedy, 1929:980, records this species from Kauai, but his record may be in error. Perkins noted that it occurs on "All the Islands from Oahu to Hawaii inclusive.")

I believe that Williams (1936:324) was the first to publish the synonymy of *calverti*. He obtained the facts from Dr. Perkins, who wrote to him (June 14, 1935) as follows:

*A. hawaiiense* was for long a mystery to me. I did not get it at all in my earlier collecting. The first specimen I obtained must have been a stray one as it occurred on one of the high ridges I believe between Manoa and Pauoa and I never got another there. I described it as *Calverti*, n. sp. partly no doubt because Blackburn said that *hawaiiense* occurred at no great elevation above the sea and partly because I thought M. L.'s *hawaiiense* must have the appendages more different from those of *deceptor*, as he said nothing about their similarity. It was only later when I found *hawaiiense* in abundance on the Palolo stream and knew what a favorite collecting ground of Blackburn's this valley was, that I knew my *calverti* would be a synonym. Also I got hold of the sorry remnants of Blackburn's coll. which settled the matter. (these remnants were incorporated with my specimens now in Bishop Mus.) . . . The limited distribution of *hawaiiense* seemed very curious, as if it were a very localized race of *deceptor*. . . . Also at no great distance up Palolo, just above the point at which I used to leave the stream and go up a ridge (on the way to the crater) there was much *ieie*. Just before going up this, *hawaiiense* abounded in the stream bed around the pools—it was hardly flowing—and I found *Agrion* nymphs quite *above* the actual water in the moss growing on some of the rocks, as well as in the water. Some of these must have been *hawaiiense* as it and *nigrohamatum* were the only species round the pools at the time.

One of the principal characters used to separate *deceptor* from *hawaiiense* was the form of the superior appendage of the male terminalia. If there was a small tooth on the lower edge, the specimen was considered to be *deceptor*; if there was no tooth, the example was called *hawaiiense*. This is a highly variable and valueless character in this species. I have examined a series of males from various localities and have drawn a number of superior appendages to show how variable they are. *M. hawaiiense* is a variable species, and inasmuch as I have been unable to demonstrate specific differences between it and *deceptor*, I have reduced the latter to a synonym. The name *hawaiiense* has been used for the dark-bodied form from Oahu, and *deceptor* has been used for the usually red-bodied male form. Although the males of what has been called *deceptor* from Molokai, Lanai, Maui and Hawaii are normally largely red-bodied, melanistic males are common.

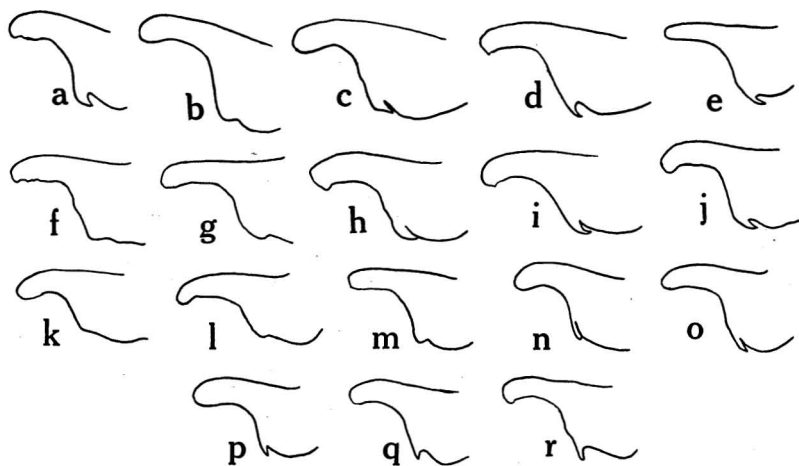


Figure 205—Sketches of lateral views of superior appendages of the male terminalia of various specimens of *Megalagrion hawaiiense* (McLachlan) to show the range of variation. a-e, Lateral views of superior appendages of examples from different localities: (a) Kilauea, Hawaii; (b) Haleakala, Maui, 8,000 feet; (c) Iao Valley, Maui; (d) Molokai; (e) Oahu. f-j, From a series of specimens taken at random from a set of males of the red form taken at the same time and place, Kula Pipe Line, Maui (Swezey, collector). k-r, From a random selection of eight specimens from a set taken by Perkins at the same time and place in Palolo Valley, Honolulu.

Williams (1936:324) said of the dark Oahu form (*hawaiiense*), "This is a damselfly of medium size that is largely metallic green in color, there being also some pale yellow on the thorax and very narrow bands of that color on the abdomen. It inhabits the canyons of both mountain ranges of Oahu, where I have found it at an elevation of less than 1,000 to nearly 4,000 ft. above the level of the sea."

Williams (1936:324-328, figs. 79, nymph; 86, gill; 116, male terminalia) made a detailed study of this species, and the following material is taken from his account. The eggs, which are about 0.8 mm. long, were found to be inserted in decaying or tender living plant material in very shallow water or on wet banks. The nymphs measure about 18 mm. in length when full-grown. They lead almost a terrestrial

life and live in the thinnest sheets of water on wet rocks or dripping banks. Williams calls them "rock creepers," and he occasionally found them crawling about completely out of the water. The nymphal food includes the larvae of the crane fly, *Limonia* (*Dicranomyia*) *grimshawi* (Alexander), oribatid mites, *Scatella* and other flies and their larvae, ants, Crustacea, etc. Williams found what he considers to be the nymphs of what was formerly called *deceptor* in a stream at 5,000 feet on Mauna Kea, Hawaii, and found that they fed mostly on *Tanytarsus* (Chironomidae).

Blackburn mistook what was later named *jugorum* by Perkins for this species (see note under *jugorum*), and he called this species *calliphya* (see note under *calliphya*). When Blackburn sent the male type to McLachlan, he thought that it was the same as what McLachlan described as *oceanicum*.

**Megalagrion heterogamias** (Perkins) (figs. 199, b; 207).

*Agrion heterogamias* Perkins, 1899:77, pl. 5, fig. 3.

*Megalagrion heterogamias* (Perkins) Kennedy, 1917:13, figs. 21, 22, penis.

Endemic. Kauai. Perkins did not give the exact locality of the type, but he mentioned (1899:77) that the species was widespread from about sea level to about 4,000 feet elevation.

This species is allied to *oceanicum*, *jugorum*, *molokaiense* and *blackburni*. Little is known about its early stages. Perkins (1913:clxxviii) found the nymphs "numerous amongst dead decaying leaves lying on the ground, and saturated with the wetness oozing from a perpendicular bank, at the foot of which they lay. There was no standing water, and the spot was at some distance from a river, and had no connection with this."

**Megalagrion jugorum** (Perkins) (figs. 199, g; 207).

*Agrion jugorum* Perkins, 1899:72, pl. 5, figs. 2, 11, 11a.

*Megalagrion jugorum* (Perkins) Kennedy, 1917:11.

Endemic. Lanai, Maui (type locality not specifically designated by Perkins).

Perkins stated that the species was found in the mountains of Lanai and the high ridges of West Maui at 4,000 feet, but nothing has since been recorded for this species.

Blackburn's example of this species is in Perkins' collection at the Bishop Museum. It was labeled *deceptor* by Blackburn, and has a label attached by Perkins which reads, "*A. deceptor* McL. sec. T.B.!! really *A. jugorum*."

This is a rare species belonging to the *blackburni* complex.

**Megalagrion kauaiense** (Perkins) (figs. 198, g-i; 207).

*Agrion kauaiense* Perkins, 1899:75; 1913:clxxvii, fig. 1a, 1b.

*Megalagrion kauaiense* (Perkins) Kennedy, 1917:11.



Endemic. Kauai (type locality not definitely stated with original description, but the species was recorded as having been widely distributed from 2,000 to 4,000 feet altitude).

This species, an ally of *williamsoni*, *eudytum* and *adytum*, is unknown in its immature stages.

**Megalagrion koelense** (Blackburn) (figs. 194; 195; 201, c; 207; 211).

*Agrion* ? *koelense* Blackburn, 1884:417.

*Agrion koelense* Blackburn, Perkins, 1899:65 (Note: pl. 5, figs. 7 and 7a do not apply to this species, but refer to *amaurodytum*. See Perkins, 1912:180, for explanation, and see note below).

*Megalagrion koelense* (Blackburn) Kennedy, 1917:13, figs. 27, 28, penis.

*Agrion asteliae* Perkins, 1899:66 (type locality: Oahu, 3,000 feet).

*Megalagrion asteliae* (Perkins) Kennedy, 1917:11, figs. 29, 30, penis. New synonym.

Tillyard (1917:103–106, figs. 30–32) discusses the gills of the nymphs of this species under the name of *asteliae*.

Endemic. Oahu, Lanai (type locality: a ravine near Koele), Maui, Hawaii.

This species is variable and confusing, the problems concerning it are involved and they cannot be answered in this work. However, I have synonymized *asteliae*, because I have been unable to find any constant characters to separate the two forms. An outline of some of the problems follows.

Perkins (1912:180) said, "Whether Blackburn's *A. koelense* is what I considered it is, or what I have called *A. amaurodytum*, I cannot tell with certainty till I examine his species. The members of the 'Koelense' group of Agrions, that superficially resemble one another, show much variability, the species are closely allied, and frequently occur mixed in the field, so they are not extraordinarily easy to distinguish." Blackburn's type material was later obtained by Perkins and is now in the Bishop Museum.

From the habits and gross features of the nymphs and adults, Williams was unable to differentiate between *asteliae* and *koelense*, and he notes (1936:333) that "*Megalagrion koelense* (Blkb.) and *M. asteliae* (Perk.) are very closely allied species best separated by the rather slight differences in the male claspers. They average a little smaller than *M. amaurodytum*. *M. asteliae*... on Oahu may fly with *M. koelense*."

Perkins (1899:66) said of *asteliae*, "A single pair taken in copula at Kilauea, Hawaii (4000 feet). The individuals from the two Islands [Oahu and Hawaii, i. e.] do not altogether agree, but I doubt whether they could be separated even with a long series of examples." When I first began this study, I noted that this distribution of *asteliae* inhabiting only Oahu and Hawaii, and *koelense* inhabiting Oahu, West Maui and Lanai, was very unusual. At that time I wondered if some error had not arisen as to locality or identification of the specimens of *asteliae* from Hawaii. I also considered the possibility that *asteliae* might be a form of *koelense*

and that the "species" was distributed from Oahu to Hawaii. However, the drawings of the penes given by Kennedy (1917:13, figs. 27-30) show what appear to be clear-cut differences which would nullify such an argument. The specimens of both *asteliae* and *koelense* used by Kennedy for his drawings came from the same place on Oahu (Mount Tantalus) and were collected by Perkins after the Odonata part of the *Fauna Hawaiiensis* was published. Perkins listed *koelense* only from Lanai and West Maui in his original report, but later (1906:50) noted that he found *koelense* very common on Mount Tantalus, Oahu.

In preparing the final part of this manuscript, I studied the penes of specimens from Perkins' collection and found that in both his series of *asteliae* and *koelense* there was obvious variation in the form of the penes. I have been unable to match exactly Kennedy's drawings. No two penes are completely alike. Kennedy's drawings appear in part to be diagrammatic, and one can be grossly misled by considering them representative of constant characters. I have come to the conclusion that it is not possible to separate *asteliae* from *koelense* by the characters of the penes—they are obviously variable. Moreover, the terminalia of the males upon which so much reliance is placed are also variable. Perkins (1912:181) gives a key to separate *amaurodytum*, *asteliae* and *koelense* based upon the form of the male terminalia.

The following information is of value and should be placed in the published record. In Perkins' material sent to the Bishop Museum is the specimen used for plate 5, figures 7, 7a, of his original *Fauna Hawaiiensis* report (1899), which illustrations I have noted above belong to *amaurodytum*. This example bears the label "*A. koelense*, near Koele, Lanai, 2000 feet, January 1894," and the following explanatory note written by Perkins: "This spec. was fig. in F. H. as *koelense* (V.7 and 7a) but is *amaurodytum*, not otherwise known from Lanai. I cannot help thinking that some mistake was made as to locality. The specimen was picked from the series of *koelense* for Wilson to figure because the terminal segments were separated and easy for him to handle, and no doubt was not specially examined by me before I gave it to him, as I had no suspicion that there was a wrongly named specimen in the Lanai series. Most likely one of the untrained boys in the Museum who labeled the insect made some mistake in labeling etc. The occurrence of *amaurodytum* on Lanai needs confirmation and the description pl. V. fig. 7 and 7a should read *amaurodytum* for *koelense*. R.C.L.P."

In a box of 49 specimens labeled *koelense* by Perkins is a note reading, "15 exx. on ridge above Palolo, settling on ieie vines, taken in cop. V-1912. Larvae numerous in the ieie leaves. R.C.L.P." ("Ieie" is the Hawaiian name for *Freycinetia*.) A note on one specimen reads, "This spec. was watched ovipositing in leaves of *Freycinetia*, not at base, but 1/3 from apex of the leaf." A female in Perkins' *asteliae* series bears the following label, "This was under *asteliae* in collection but looks to me casually more like *koelense*. 14-iv-29. R.C.L.P." It is evident that Dr. Perkins himself had difficulty in distinguishing these forms.

Dr. Williams (1936:333-339) has studied this species in detail in the field, and the following notes are based upon his observations. The pale-brown eggs,

which are about a millimeter long, are inserted in the midribs of the leaves of *Freycinetia* and/or *Astelia*. The females were observed to cling to the leaf above that in which the eggs were to be inserted, then extend the abdomen down to the leaf below and cut a slit in which the eggs were laid. Williams found that this species usually inserted a pair of eggs in each puncture, whereas the other species studied laid but a single egg in a puncture. The sites of oviposition are conspicuous in the leaves. The incubation period was found to be about three weeks. The nymphs are greenish brown to dark brown in color, and when full-grown measure about 18 mm. in length. They live in the axils of the leaves where water and trash collect, but they are able to withstand drying. The species now inhabits the mountains from about 1,000 feet upward. The nymphal food consists of many kinds of insects and other arthropods, including small wasps, bugs, carabid beetle larvae, various flies, damselfly nymphs, mites, spiders, isopods, amphipods, molluscs, etc. Perkins (1913:clxxix) said, "In wet weather, when a little water may collect at the bases of the leaves of the *Astelia* we have noticed that the nymphs will often be found to have crawled half-way up the leaf, as if they actually disliked the wet!"

This is one of the commoner species and can be found easily in the wet mountains where *Freycinetia* grows. It is peculiar that it has not been found on Molokai.

**Megalagrion leptodemas** (Perkins) (figs. 180, B; 196, b, f; 200, b; 206; 212).

*Agrion leptodemas* Perkins, 1899:70.

*Megalagrion leptodemas* (Perkins) Kennedy, 1917:12, figs. 5, 6, penis.

Williams, 1936:304, illustrated.

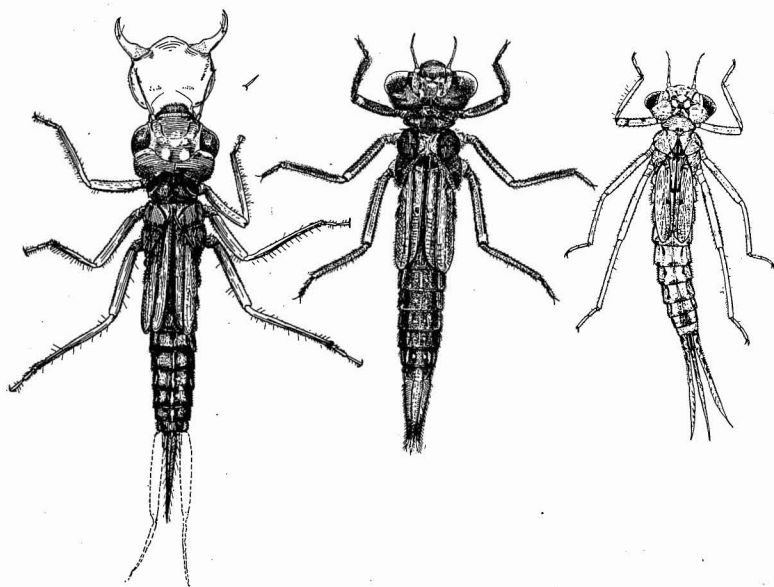


Figure 206—Naiads of *Megalagrion*: left, *M. nigrohamatum* (Blackburn), last stage, about 18 mm. long; middle, *M. hawaiiense* (McLachlan), last stage, 15.5 mm. long; right, *M. leptodemas* (Perkins), last stage, 14.2 mm. long. (From Williams' original drawings.)

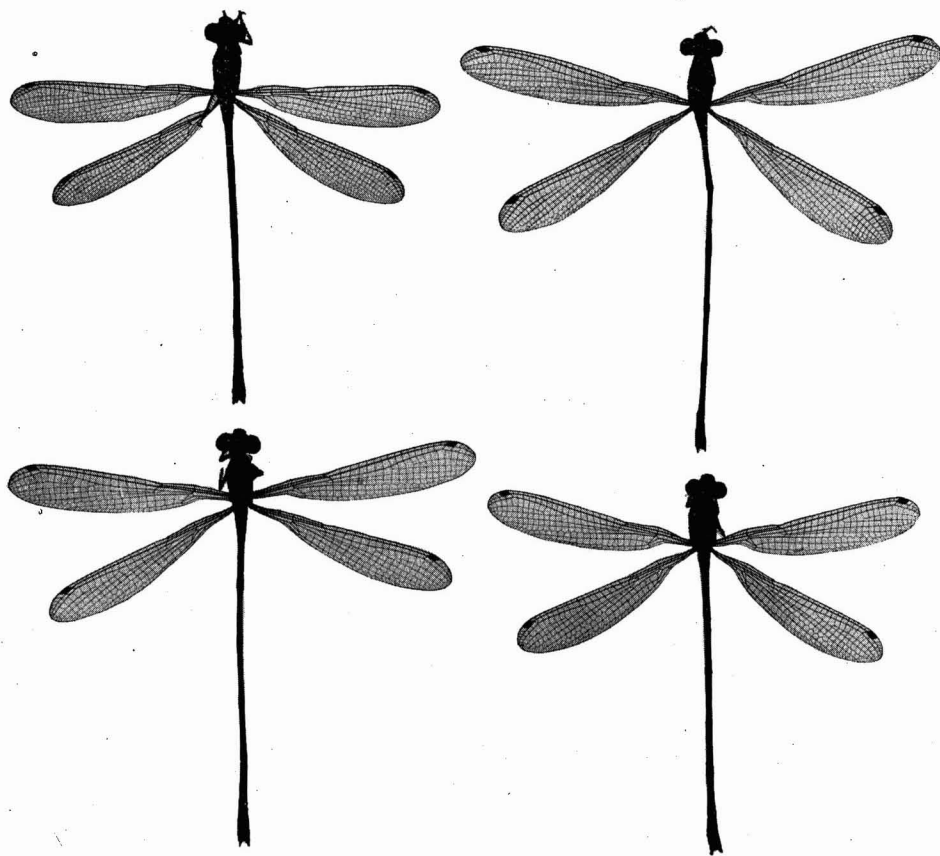


Figure 207—*Megalagrion*. Top: *M. heterogamias* (Perkins), left; *M. jugorum* (Perkins), right. Bottom: *M. koelense* (Blackburn), left; *M. kauaiense* (Perkins), right. (Not to same scale.)

Endemic. Oahu (type locality: "Halemano," above 2,000 feet).

This species was described from a unique, but Perkins collected a series of specimens after the *Fauna Hawaiiensis* was published. Williams (1936:304-309) studied the species and has given us a good account of its habits. He says that "This is one of our smaller and more slender species. The male has a very red face—below the antennae—part of the thorax is red and the abdomen is red except for the intermediate portion. The female is more soberly colored; the abdomen while reddish at its extremity is for the most part blackish. It is sometimes abundant back of Honolulu. . . ." The life cycle of a reared example from egg to adult was four months. The eggs are inserted in plant tissue lying in water and may hatch in about two weeks. The nymphs are entirely aquatic, 17 to 18 mm. long when full-grown, and they have been well described by Williams. They live in mountain streams and stream pools where they feed largely upon dipterous larvae

such as *Culex* mosquitoes and chironomids, but other available arthropods are eaten. Williams notes that the nymphs closely resemble those of *M. xanthomelas*.

**Megalagrion molokaiense** (Perkins) (figs. 199, d; 208).

*Agrion molokaiense* Perkins, 1899:73.

*Megalagrion molokaiense* (Perkins) Kennedy, 1917:11.

*Hawaiiagrion molokaiense* (Perkins) Kennedy, 1920:86.

Endemic. Molokai (type from the east Molokai mountains about 4,000 feet).

The habits of this species are unknown. It is closely allied to *M. jugorum*, and I feel that further study may show that it is a local form of that species and hardly entitled to specific rank. It belongs to the *heterogamias*, *oceanicum*, *blackburni*, *jugorum* complex.

**Megalagrion nesiotes** (Perkins) (figs. 199, c; 212).

*Agrion nesiotes* Perkins, 1899:72, pl. 5, figs. 10, 10a.

*Megalagrion nesiotes* (Perkins) Kennedy, 1917:13, figs. 37, 38, penis; 1934:343, figs. 6-10.

*Kilauagrion nesiotes* (Perkins) Kennedy, 1920:86. Genotype of *Kilauagrion*.

*Megalagrion dinesiotes* Kennedy, 1934:343, figs. 1-5. New synonym. (In my reprint of Kennedy's paper, he wrote, "Later material intermediate between this and *nesiotes*, therefore probably a synonym.")

Endemic. Maui (type locality of *dinesiotes*), Hawaii (Perkins did not state where the holotype came from, and his type series was taken at a number of different localities on Hawaii).

The life history of this species is unknown.

**Megalagrion nigrohamatum nigrohamatum** (Blackburn) (figs. 197, a; 201, e; 206; 212).

*Agrion* ? *nigro-hamatum* Blackburn, 1884:415.

*Coenagrion Nigrohamatum* (Blackburn) Kirby, 1890:151.

*Agrion nigro-hamatum* Blackburn, Perkins, 1899:65, pl. 5, figs. 5, 5a.

*Megalagrion nigrohamatum* (Blackburn) Kennedy, 1917:13, figs. 31, 32, penis.

*Hawaiiagrion nigrohamatum* (Blackburn) Kennedy, 1920:86.

Williams, 1936:318-320.

Endemic. Oahu, Molokai, Maui (type locality), Hawaii.

This is one of the commoner native damselflies, and it is found from near sea level to a few thousand feet up the mountains. "The bright yellow face and the

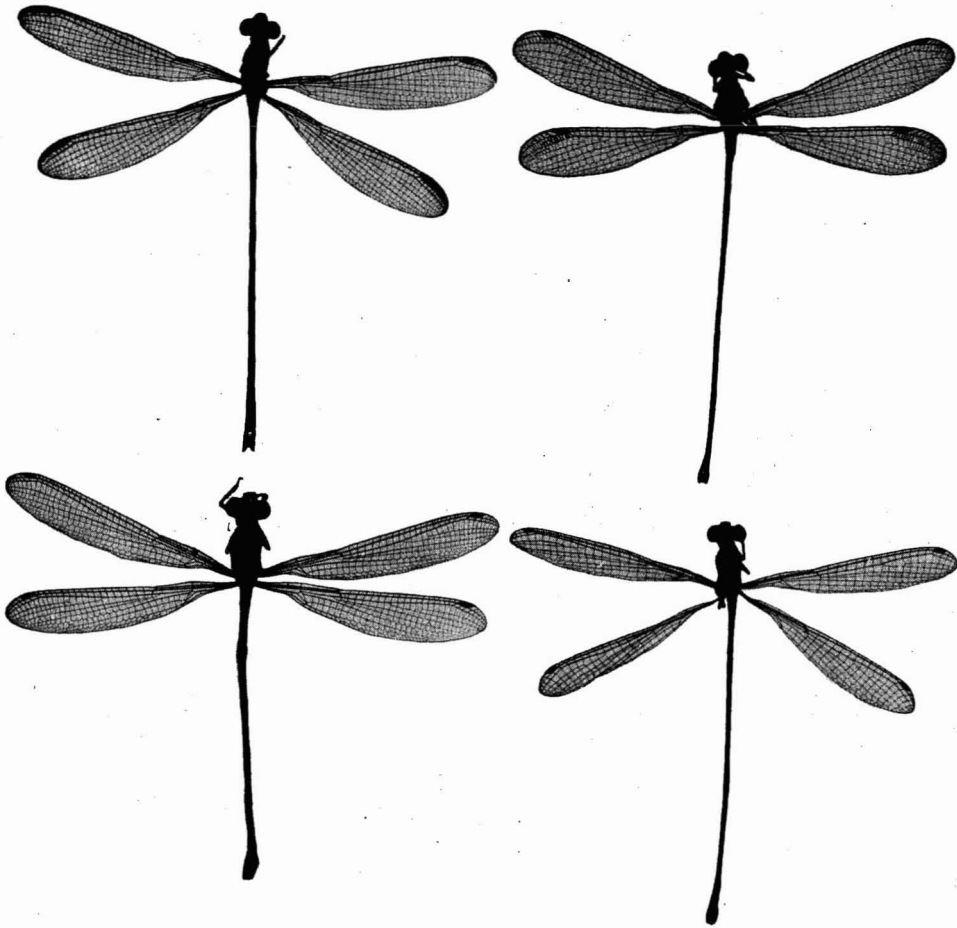


Figure 208—*Megalagrion*. Top: *M. molokaiense* (Perkins), left; *M. oahuense* (Blackburn), right. Bottom: *M. oceanicum* McLachlan, left; *M. oresitrophum* (Perkins), right. (Not to same scale.)

colour of the eyes, which are bright green or turquoise blue on the lower half, and red on the upper, give this species a most remarkable appearance when flying around the streams. The colour of the eyes fades after death." (Perkins, 1899:65.) Williams (1936:318) states that "In the typical form *M. nigrohamatum* from Maui and Molokai, the knees of the legs are black, while in the race *nigrolineatum*, from Oahu and itself on the average a smaller insect, there is in addition, a black line along the upper side of the femora."

This is one of the species which breeds in streams and pools. The eggs are inserted in plant tissue in or near water. Unlike some of the other species whose larvae live exposed, these nymphs prefer to conceal themselves, for Williams found

the brown nymphs under stones and in masses of algae. The nymphs are described by Williams (1936:318), who found that they feed upon *Culex* and *Tanytarsus* larvae and other available material.

**Megalagrion nigrohamatum** variety **nigrolineatum** (Perkins) (figs. 196, c; 197, d; 212).

*Agrion nigro-hamatum* race *nigro-lineatum* Perkins, 1899:65.

*Megalagrion nigrohamatum nigrolineatum* (Perkins) Kennedy, 1917:13, figs. 33, 34, penis.

*Hawaiiagrion nigrohamatum nigrolineatum* (Perkins) Kennedy, 1920:86.

Endemic. Oahu, Hawaii (Perkins did not designate a type locality).

The notes on the habits of the typical form apply to this variety. Perhaps if a long series of examples were examined from many localities it would be evident that the species is quite variable. Certainly the distribution is unnatural and reflects our incomplete knowledge of the form. I call it a variety instead of a race.

**Megalagrion oahuense** (Blackburn) (figs. 194; 195, d; 201, f; 208; 209; 210).

*Agrion* ? *oahuense* Blackburn, 1884:415.

*Coenagrion Oahuense* (Blackburn) Kirby, 1890:151.

*Agrion oahuense* (Blackburn) Perkins, 1899:74, pl. 5, figs. 12, 12a.

*Megalagrion oahuense* (Blackburn) Kennedy, 1917:13, figs. 25-26, penis.

*Oahuagrion oahuense* (Blackburn) Kennedy, 1920:86. Genotype of *Oahuagrion*.

Williams, 1936:339-347, figs. 9, 10, 117, 123-128, bionomics.

Endemic. Oahu (exact type locality not recorded, but probably from the fore hills behind Honolulu).

To Dr. F. X. Williams great credit is due for his efforts and perseverance in making known the remarkable life history of this peculiar damselfly. Time and again he made arduous and diaphoretic field trips up the steep mountains of Oahu to track down and reveal the unique habits of this outstanding damselfly. I have been with Williams on some of his many trips, and I am entirely aware of the difficulties, time and labor involved during his research which cannot be appreciated fully by those unacquainted with the task. His long search was fruitful, and his outstanding contributions to Hawaiian entomology speak for themselves.

It "...is a rather large damselfly of very slender form.... The colors are somewhat dull, particularly in the female and consist chiefly of red, brown and pitchy black with some bronzy green on the thorax. Structurally, this species stands well apart from the others; the male is readily identified by his peculiarly shaped terminal claspers... the female by the tuft of tawny hair just behind each mesostigmal plate on the fore part of the mesothorax above..." (Williams, 1936: 339-340).

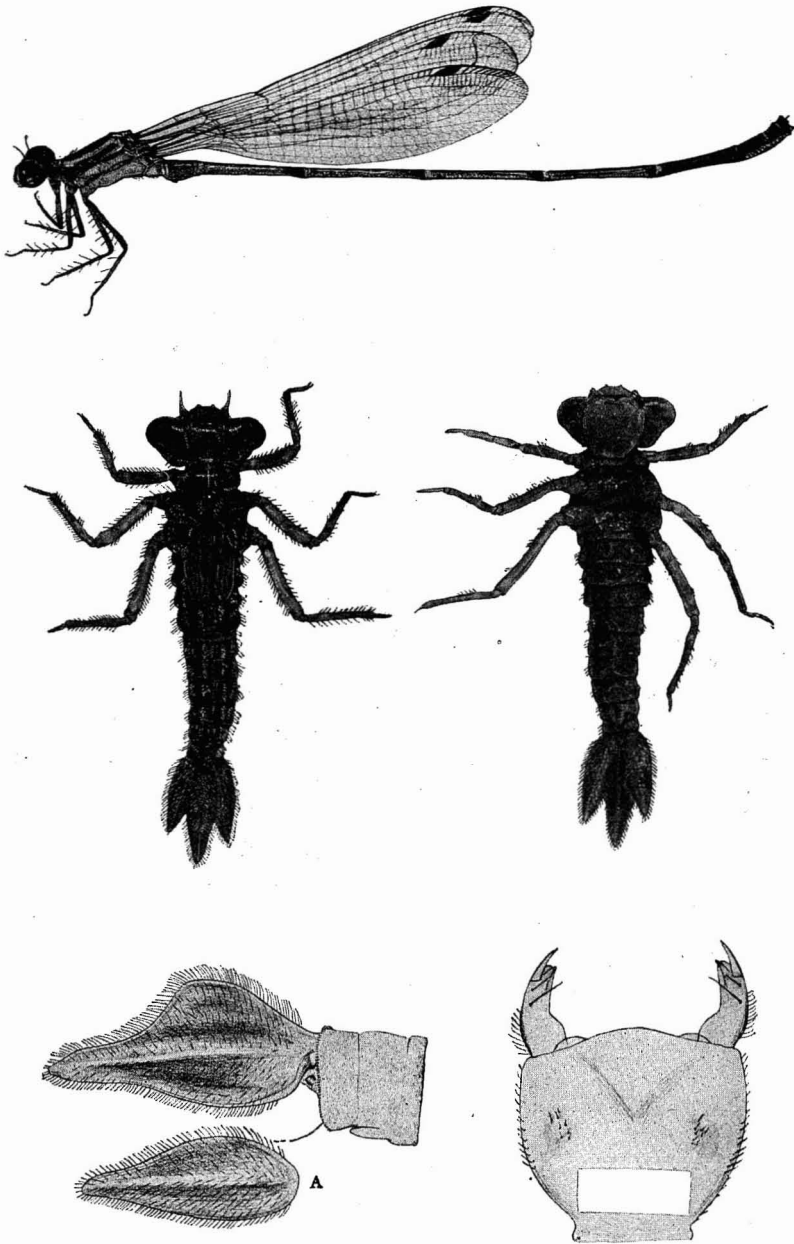


Figure 209—*Megalagrion oahuense* (Blackburn). Male at top. Middle: dorsal and ventral views of penultimate stage female naiad. Bottom, left: median and lateral gill (A) of above naiad; bottom, right: labium of above naiad from the inside to show two large setae on each side of the lateral lobes and two groups of small setae on the median lobe. (After Williams, 1936.)



In *Fauna Hawaiiensis*, Perkins (1899:74) gave the following notes: "High ridges of mountains of Oahu (3000 ft.). Nymphs living between the leaves of *Astelia veratroides*." Williams found that Perkins' assumption that the nymphs lived in *Astelia* plants was incorrect, and that the species has the most remarkable life history of any known member of the Odonata. Instead of being aquatic, this species is terrestrial! The eggs, which are pale orange and about 0.8 mm. long, are laid among the trash found under thickets of *Gleichenia linearis* fern. The nymphs, which inhabit the damp trash or leaf mold in the dense shade of the fern thickets, are the most hairy of the known Hawaiian nymphs. It appears that the development of the body hairs has to do with the retention of moisture on the nymphs' bodies. The gills are peculiarly formed, swollen and densely hairy. The length



Figure 210—A thicket of *Gleichenia linearis* fern growing on the slope of a ridge behind Honolulu showing where Dr. F. X. Williams found the remarkable terrestrial naiads of the native damselfly, *Megalagrion oahuense* (Blackburn). The fern is about three feet tall, and the foreground has been cleared in searching for the naiads. (After Williams, 1936.)

of the life cycle and the food of the nymphs have not yet been ascertained. The adults are on the wing throughout the year. They are usually low flyers and skim over the vegetation in search of such prey as midges. They also pick up insects, spiders and mites which are crawling on vegetation. The reader should consult Williams' classic discussion of his studies of this remarkable insect. The type of the species is now in the Bishop Museum. (See also my comments on page 343.)

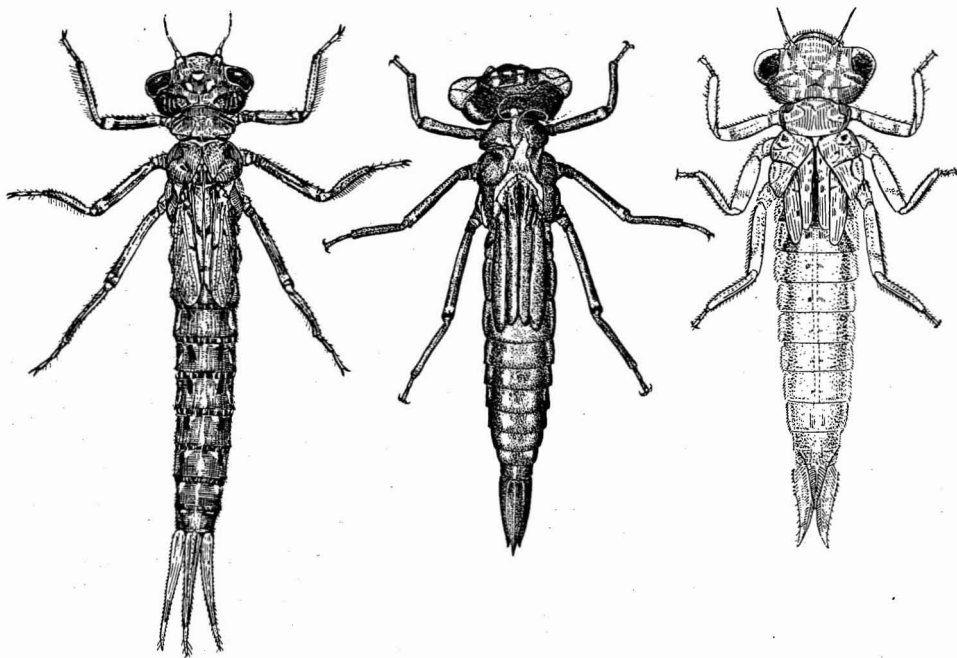


Figure 211—*Megalagrion* naiads: left, *M. oceanicum* McLachlan, last stage, 21.5 mm. long; middle, *M. amaurodytum waianaeaeum* (Perkins), cast skin from which the adult shown in figure 203 emerged, length 17.25 mm.; right, *M. koelense* (Blackburn), probably penultimate stage, 12.5 mm. long. (From the original figures for Williams, 1936.)

***Megalagrion oceanicum* McLachlan** (figs. 194; 196, d; 201, a; 203; 208; 211).

*Megalagrion oceanicum* McLachlan, 1883:239.

*Agrion oceanicum* (McLachlan) Perkins, 1899:76, pl. 5, figs. 14, 14a; describes female.

Kennedy, 1917:13, figs. 19, 20, penis. Williams, 1936:320–323, figs. 78, 88, 94, 95, 98, bionomics.

Endemic. Oahu (type locality: "at no great elevation above the sea").

This species, with *blackburni* and *heterogamias*, includes our largest and most conspicuous damselflies. The eggs of this species are inserted, often in great numbers, in the tissues—stems, leaves or roots—of several kinds of plants grow-

ing in or near water. The nymphs, which measure as much as 25 mm. in length when mature, are rather versatile in their habits. They have been found under stones and among roots and algae in running water; they swim well, but crawl up dripping wet banks, mossy rocks, and tiny waterfalls, and may leave the water and hunt about in moist places. They seem to prefer very shallow water and are better creepers or crawlers than swimmers. Their diet includes a variety of food among which Williams (1936:322) has found chironomid, ceratopogonid, tipulid and ephydrid fly larvae, caterpillars, Collembola, beetle larvae, adult flies, mites and earthworms. Williams found them to be easily reared in the laboratory. Perkins (1913:clxxviii) noted that the young nymphs were eaten by *Rhantus pacificus* (Coleoptera: Dytiscidae).

This elegant species belongs to a group whose bright-red abdomens are striking; it also has females which have black abdomens. In Perkins' box of this species

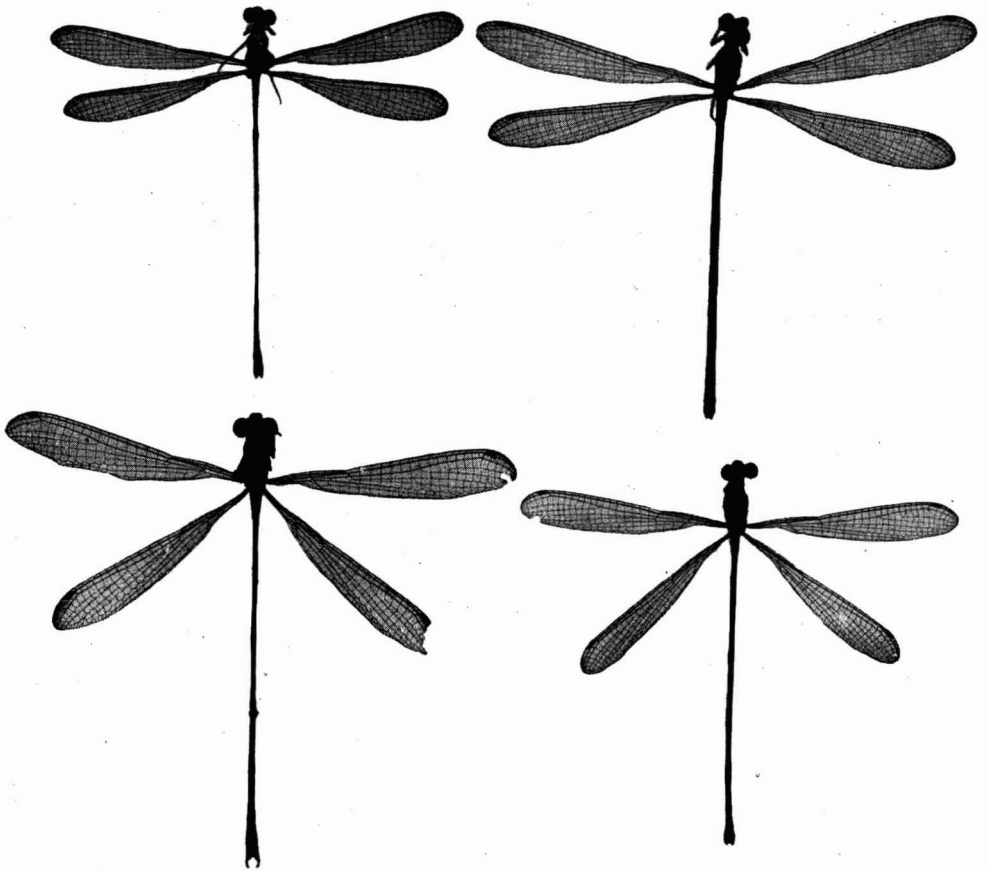


Figure 212—*Megalagrion*. Top: *M. leptodemas* (Perkins), left; *M. nigrohamatum nigrolineatum* (Perkins), right. Bottom: *M. nesiotes* (Perkins), left; *M. nigrohamatum nigrohamatum* (Blackburn), right. (Not to same scale.)

there is a note which reads, "The black bodied ♀ was not known to me when F. H. was written, as my specimens all came from W. side of Waianae Mts. where the ♀ ♀ were red-bodied. R.C.L.P." Also in Perkins' material is the specimen used by Wilson in preparing the illustrations of this species for *Fauna Hawaiiensis*.

**Megalagrion oresitrophum** (Perkins) (figs. 199, f; 208).

*Agrion oresitrophum* Perkins, 1899:69, pl. 5, figs. 8, 8a.

*Megalagrion oresitrophum* (Perkins) Kennedy, 1917:10.

Endemic. Kauai (type locality not designated other than in the mountains at 4,000 feet).

This species is closely allied to *leptodemas*, according to Perkins (1899:70). Nothing is known of its habits.

**Megalagrion orobates** (Perkins).

*Agrion orobates* Perkins, 1899:70.

*Megalagrion orobates* (Perkins) Kennedy, 1917:10.

Endemic. Kauai (type locality: above Waimea, 4,000 feet).

This species is said to be similar to *M. oresitrophum*. It was described from a single male specimen, and we do not have it represented in our named material at the Bishop Museum. Kennedy (1929:980) erroneously recorded the species from Oahu instead of Kauai.

**Megalagrion pacificum** (McLachlan) (figs. 200, c; 213).

*Agrion* (?) *pacificum* McLachlan, 1883:234.

*Coenagrion Pacificum* (McLachlan) Kirby, 1890:151.

*Agrion pacificum* McLachlan, Perkins, 1899:64, pl. 5, figs. 6, 6a.

*Megalagrion pacificum* (McLachlan) Kennedy, 1917:12, figs. 1, 2, penis.

Endemic. Kauai, Oahu, Molokai, Lanai, Maui, Hawaii (type material from Maui and Lanai at various elevations, not Lanai and Oahu as stated in original description; corrected by Blackburn, 1884:417).

Although this species is widespread and occurs at low elevations, its early stages have escaped general notice. In a letter to F. X. Williams, June 14, 1935, Dr. Perkins said "N.B. By an oversight on p. clxxviii F. H. line 24 '*hawaiiense*' should be *pacificum*, which is the stagnant water or pond species in so many localities. This and other errors I did not get a chance to correct in the final proof, when I was in Honolulu, as my returned corrections were too late!" Perkins' record (1913:clxxviii) on the early stages of this species reads, corrected, "*A. pacificum*, another small species, is more local than the preceding [*xanthomelas*], but also

seems to generally breed in stagnant water. When it frequents streams, like that of the Iao valley on Maui, we have noticed that its chief haunts are quiet small pools, often cut off, or at a distance, from the main stream. It also breeds numerous in upland ponds of considerable size, where these occur." Williams did not find the nymphs during his intensive research on the genus on Oahu.

**Megalagrion vagabundum** (Perkins) (figs. 199, e; 213).

*Agrion vagabundum* Perkins, 1899:75, pl. 5, figs. 13, 13a.

*Megalagrion vagabundum* (Perkins) Kennedy, 1917:13, figs. 23, 24, penis.

Endemic. Kauai (type series from 1,000- to 4,000-foot elevation, but no holotype locality given by Perkins).

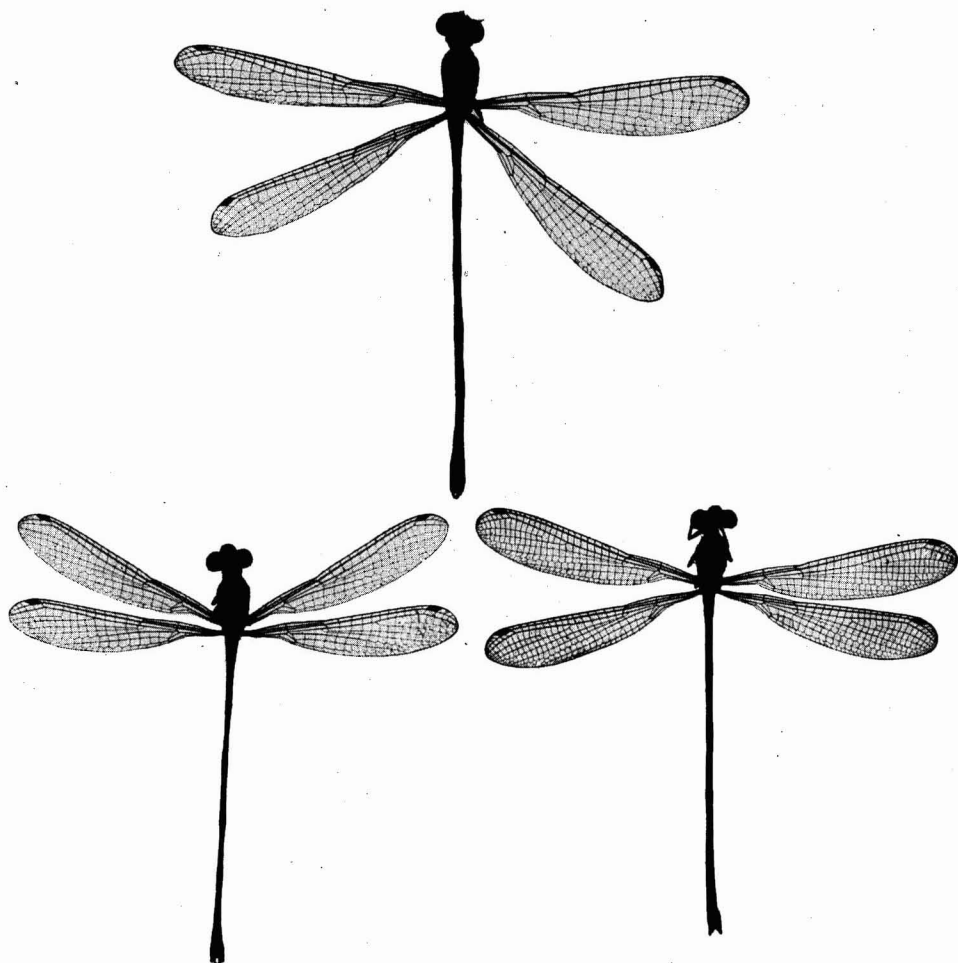


Figure 213—*Megalagrion*. *M. pacificum* (McLachlan), top; *M. xanthomelas* (Selys-Longchamps), bottom left; *M. vagabundum* (Perkins), bottom right.

Perkins found this species widespread in the mountains of Kauai. The life history is unknown. It is closely allied to *kauaiense* and appears to form a connecting link between *kauaiense* and *hawaiiense*. Judging from the male terminalia, *vagabundum* appears to be a *kauaiense* which has lost the apical tooth on the lower inner margin of the superior appendages.

**Megalagrion williamsoni** (Perkins) (fig. 198, a-b).

*Agrion williamsoni* Perkins, 1910:696.

*Megalagrion williamsoni* (Perkins) Kennedy, 1917:10.

Endemic. Kauai (type locality: "near Lihue on a mountain stream").

The unique male holotype of this species is in the Bishop Museum. Nothing is known regarding the habits of this species, which belongs to the *kauaiense* group.

**Megalagrion xanthomelas** (Selys-Longchamps) (figs. 180, C; 195, a, c; 201, d; 213).

*Agrion* (?) *xanthomelas* Selys-Longchamps, 1876:174. McLachlan, 1883:232.

*Coenagrion* (?) *Xanthomelas* (Selys-Longchamps) Kirby, 1890:150.

*Megalagrion xanthomelas* (Selys-Longchamps) Kennedy, 1917:12, figs. 3, 4, penis.

*Hawaiiagrion xanthomelas* (Selys-Longchamps) Kennedy, 1920:86. Genotype of *Hawaiiagrion*.

Williams, 1936:310-316, figs. 76, 89-91, 93, 104, bionomics.

Endemic. Oahu, Molokai, Maui, Hawaii (type from "Iles Sandwich").

I have been unable to find any definite records of this species being found on Kauai, or Lanai, but Kennedy records it from both islands. Perhaps he followed Perkins' statement (1899:64) that the species "Probably occurs all over the islands." It may occur on Lanai and Kauai, but I have seen no specimens or authentic records from those islands.

Perkins (1913:clxxviii) said that this "is a common insect in Honolulu gardens and in lowland districts generally, not usually partial to the mountains, though in the Kona district of Hawaii it is common about stagnant pools up to an elevation of about 3000 feet. It is very numerous in individuals under conditions totally changed from the natural; perhaps it now finds more numerous breeding places, and a more abundant prey in the numerous insects that have been introduced by man in the region it frequents." The introduction of *Gambusia* top minnows ("mosquito fish") has changed the lowland situation considerably in recent years, however, and the species is much less abundant than formerly.

The eggs, which are almost a millimeter long and amber in color, are inserted singly in punctures in such plants as *Commelina nudiflora* and *Marsilea villosa* near or beneath the surface of the water. The nymphs, which vary in color from greenish to dark brown and black are about 18 mm. long when full-grown, are entirely aquatic and are good swimmers. Their food consists principally of various aquatic dipterous larvae and the usual food materials available in ponds.

This was the first of the Hawaiian damselflies to be described. The type material was collected by G. F. Mathew, R.N.

### Genus **ISCHNURA** Charpentier, 1840

This is a cosmopolitan genus of small damselflies known as "fork-tails" (this from the nymphs). Although the genus reaches its greatest development in the south and west Pacific, we have had no representative of the genus in Hawaii until recently when an immigrant became established. The structure of the wings, as mentioned in the key, and the form of the male terminalia readily serve to separate this genus from the two other genera of damselflies found in Hawaii.

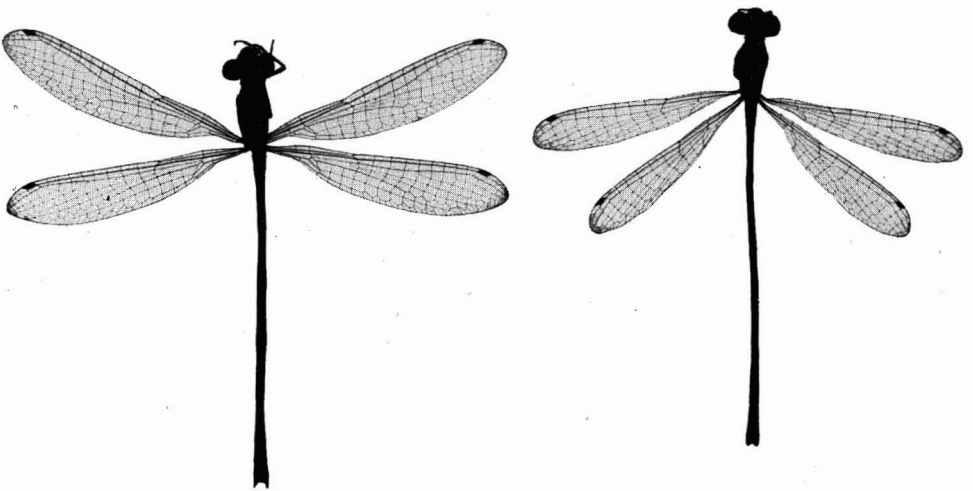


Figure 214—*Enallagma civile* (Hagen), male, left; *Ischnura posita* (Hagen), male, right.

**Ischnura posita** (Hagen) (figs. 214; 215, b-d).

*Agrion positum* Hagen, 1861:77.

Garman, 1917, gives good figures.

Oahu.

Immigrant. A common and widespread North American species. First found by Hoyt breeding in a lily pond in Honolulu in 1936.

Byers (in Needham and Heywood, 1929:350) gives a description of this species together with a figure of the male terminalia and a table of the nymphal characters. The nymphs, which measure about 17 mm. over-all when full-grown, can be separated from the nymphs of *Enallagma*, which they closely resemble, because they have long, slender, tapering gills (see fig. 215, b-d) instead of blunt ones. The nymphs I have seen have been a delicate green in color. The abdomen of both sexes in the adult has the tergites black with yellow basal bands on segments three to seven and blue on the apices of segments eight and nine.

The eggs are inserted singly in plant tissues and the species breeds in ponds. No detailed investigation of the life history and habits of this species has been made in Hawaii, but Williams has reared it from eggs laid in *Pistia* plants (*Proc. Hawaiian Ent. Soc.* 12[2]:221, 1945).

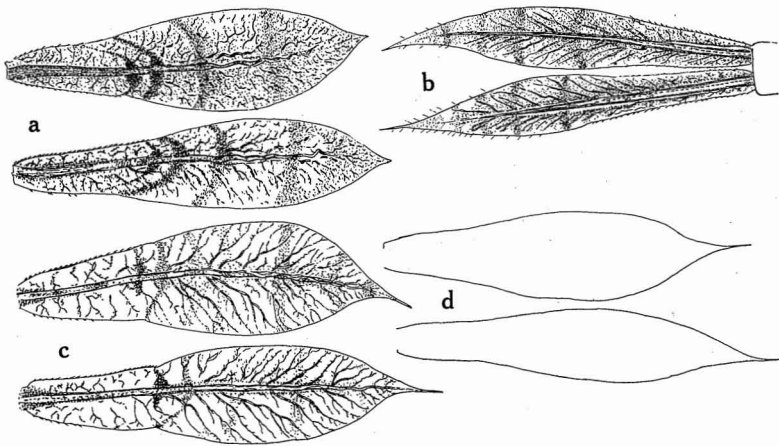


Figure 215—Caudal gills of our immigrant damselfly naiads: a, median and lateral gills of last stage naiad of *Enallagma civile* (Hagen); b, the same of a penultimate stage male naiad of *Ischnura posita* (Hagen); c, the same of a last stage female naiad; d, the same of a last stage male naiad (color pattern omitted, but similar to c). (Drawn for this text by F. X. Williams.)

### Genus **ENALLAGMA** Charpentier, 1840

This is a widespread genus which is best developed in North America. The species have been called "bluets." One immigrant species from North America represents the genus in Hawaii.

***Enallagma civile*** (Hagen) (figs. 180, D; 214; 215, a).

*Agrion civile* Hagen, 1861:88.

Garman, 1917, gives good figures.

Oahu, Molokai, Maui, Lanai.

Immigrant. First found by Williams in July, 1936, at Honolulu.



Byers (in Needham and Heywood, 1929:336) discusses this species, figures the male terminalia and gives characters of the nymphs. It may be distinguished easily from all our other damselflies because of its well-marked black and beautiful blue color pattern. The blue color generally fades to yellowish or brownish after death, however. Although *Ischnura posita* also has a black and blue color pattern, that species has the abdominal segments largely black above instead of mostly blue in the male. The females of this species have the dorsum of each abdominal segment black, however. No studies of its habits in Hawaii have yet been made. Its eggs are inserted in plant tissues beneath the surface of the water. I found adults of the species common on the summit of Mount Konahuanui, Oahu, above 3,000 feet, in May, 1943. They had been probably blown up to the mountain heights from lowland pools.

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## Order THYSANOPTERA Haliday, 1836

(*thysanos*, fringe; *ptera*, wings)

### Thrips

*Hemiptera*, in part, Linnaeus, 1758, and other authors.

*Homoptera*, in part, Stephens, 1829.

*Gymnognatha*, suborder *Physopoda* Burmeister, 1838.

*Physopoda* (Burmeister) Walker, 1852; Comstock, 1888.

*Thripsina* Newman, 1855.

*Physapodes* Scudder, 1886.

Small (0.6–14 mm. in length), slender-bodied, spinose insects, usually well sclerotized and pigmented. Head hypognathous or opisthognathous, well exposed, highly modified and specialized, produced below to form a short, pointed beak or *mouth cone*, mouth parts asymmetrical; labrum asymmetrical, forming the front of the beak; clypeus obscure; cephalic sutures obscure or obsolete; mandibles asymmetrical, only the left one developed, the right one obsolete, the left one stylet-like, retractile; maxillae forming the lateral walls of the mouth cone, their palpi two- to eight-segmented, each maxilla bearing a slender, retractile *maxillary stylet*; labium forming the posterior part of the mouth cone, its palpi distal, one- to four-segmented; antennae elongate, longer than the head, filiform or moniliform, six- to nine-segmented, inserted close together on the front of the head between and beyond the eyes; compound eyes prominent, facets large, convex, round; ocelli absent in the immature stages, present or absent in the adults, present in all long-winged forms, present or absent in short-winged forms, when present usually three in number and assembled in a triangle, rarely with only two ocelli. Thorax with all three divisions well developed, prothorax free and movable, pterothorax fused. Legs ambulatory, tarsi unique in structure, one- or two-segmented, with a peculiar protrusible distal vesicle or *bladder* (characteristic of this order only) operated by blood pressure, which enables the insect to cling to and walk over various types of surfaces; with one or two claws, or claws obsolete. Wings four in number, of unique form, long, slender, membranous, not folded, carried overlapping over the abdomen when at rest; with characteristic, long, marginal fringes; veins few or absent, cross-veins rare; wings subject to much modification in form among various species and groups as follows: both sexes may be macropterous, both males and females may have macropterous and brachypterous forms, all may be brachypterous, all males and most females may be brachypterous but some macropterous females may be present, macropterous and apterous males and females may be present, all males may be apterous and the females macropterous, all males may be apterous and some females apterous and some macropterous, and in some forms both sexes may be apterous; when at rest each fore wing in the *Terrebrantia* rests upon the top of its corresponding hind wing so that the two

pairs lie parallel, but in the Tubulifera the wings are crossed and only one wing is completely visible from above; with at most two longitudinal veins and four or five cross-veins in the fore wings; wing membrane narrow, closely set on the upper surface with microtrichia in the Terrebrantia, but not so clothed in the Tubulifera, with a single row of long flight hairs usually present on the fore margin, the hairs forming a double fringe on the hind margin of the fore wings in the Terrebrantia, but double only near the apices of the fore wings in the Tubulifera; costa of hind wings with several subbasal, hooked spines which catch on a membranous fold on the underside of the fore wing scale when in flight. Abdomen with 10 exposed segments (really 11-segmented), cerci absent, caudal segments cone-shaped in the females, bluntly rounded in most males of the Terrebrantia, but tube-like and bearing a terminal whorl of long setae in the Tubulifera. Three or four pairs of spiracles present, one pair situated at the anterior mesothoracic angles, a pair on the sides of the first and eighth abdominal segments, a fourth pair situated behind the bases of the hind wings on all Tubulifera and some Terrebrantia. Ovipositor present only in the Terrebrantia, situated on the eighth and ninth sternites, curved, saw-like, with four valves, genital openings between the eighth and ninth sternites; female of the Tubulifera with the genital opening between the ninth and tenth sternites, with a heavily sclerotized, small, bar-like structure lying near the hind edge of the ninth sternite, and the basal margin of the tube entire. Males with the sexual aperture between the ninth and tenth sternites, with a copulatory mechanism which can be retracted into the ninth segment; the basal, ventral margin of the tube emarginate in the males of Tubulifera. Parthenogenesis common. Eggs reniform and inserted in plant tissue by most Terrebrantia, elongate-oval and deposited externally in the Tubulifera. Metamorphosis intermediate, but incomplete; two larval molts, followed by a prepupal stage in which the wing pads appear, the pupal stage following the third molt, and in this stage the animal becomes quiescent and has the antennae folded back over the head and the wing pads are elongated; pupation takes place on the host-plant or in the soil. Herbivorous, fungivorous or predaceous; some forms are gall-makers.

Fossil thrips have been described from ambers, copals and shales found in Miocene and Oligocene deposits. According to Essig (1942:253) there are about 2,500 described living species contained in about 350 genera now known. Thrips are an almost cosmopolitan group, and all of the continents are richly supplied with species. Although Australia and adjacent islands have one of the most diversified and rich thrips faunas, it appears that New Zealand has no endemic Thysanoptera.

The word "thrips" is the singular as well as the plural form. The use of "thrip" is incorrect. "Thrips" (masculine) is Linnaeus' original generic name which has come to be used as a common name; it means "wood louse."

There is a decided difference between the upland and lowland thrips faunas in Hawaii. Here, as on the other high islands of Polynesia where I have collected, it is of particular interest that the largest number of Terrebrantia and flower- and

foliage-feeding species is found in the drier, lowland regions—where the immigrant forms predominate—and the fungus-feeding and predaceous *Tubulifera* of cryptic habits are the ones found most commonly in the wet, highland forest zones. Many of the exposed species appear not to tolerate conditions of heavy rain, but species which are found in trash, under dead bark and in similar protected places are found throughout the mountains, even in the densest rain forests, although many immigrant *Terrebrantia* are found in the highlands and many are blown high into the mountains by winds and convection currents. However, there are certain *Terrebrantia* species which prefer the wet-land and forest conditions.

The first paper describing Hawaiian thrips is that by Kirkaldy (1907:102) in which he erected two new genera (*Agnostochthona* and *Nesothrips*) to receive two new species collected near Honolulu. This was followed in 1910 by Bagnall's paper in *Fauna Hawaiiensis* which included Perkins' collection. Almost all the material Bagnall had to work with consisted of dried, card-mounted specimens. Consequently, it has been difficult for subsequent workers to recognize many of his species. Bagnall listed 22 species, of which 15 were described as new. Seven of Bagnall's new species were described from unique specimens, some of them damaged. In 1913 Morgan included a Hawaiian species in one of his papers, but there then followed a lull in Hawaiian thrips studies until 1928 when Moulton published his "Thysanoptera of the Hawaiian Islands" in which 44 species were listed. Since 1928, however, a number of papers on Hawaiian thrips has appeared as new immigrant species have become established, damaged crops, carried plant diseases and aroused local workers to take particular interest in the order.

The order Thysanoptera is most closely allied to the Hemiptera, and, in fact, many authors have included the thrips in that order. The peculiar maxillary stylets are considered by various workers to be analogous to the maxillary forks found in the psocids and to similar structures present in the lice. The feeding mechanism and sucking pump are similar to those of the Hemiptera.

The metamorphosis of thrips is of an intermediate type, and it approaches the complete type in some instances. The larval stage is followed by a prepupal stage, in which the organism can move about but takes no food, and this is followed by a quiescent pupal stage. Some species spin cocoons in which to pupate. Although most species are oviparous, a certain few are known to be ovoviparous.

Some species crawl slowly about, but others run rapidly; some have a well-developed leaping ability and may jump off their hostplants to take flight. Some species, in both larval and adult stages, have the habit of walking about with the ends of their abdomens curved upward and forward and these forms may resemble small staphylinid beetles.

On the abdomens of some species there are series of spines which are used to arrange the long flight hairs on the wings, and the manipulation of these hairs by curving the abdomen forward is reminiscent of the flexing of the abdomen among the staphylinid beetles. The long flight hairs of the wings, so characteristic of the order, are found only on a few other groups of insects. Certain minute Hymenoptera, Lepidoptera, Trichoptera and a few families of minute Coleoptera

have very slender wings which are armed with a similar type of hair. The hairs serve to extend the wing area to sustain flight. When at rest, the hairs are folded against the wing margins.

Thrips are, in general, gregarious, and they are often found in large colonies on their hostplants. Several or many generations occur each year in Hawaii. Most or all of the life stages usually can be found together at the same time when a colony is examined.

Although certain members of this order are of decided economic importance because they cause severe damage to crops or are vectors of plant diseases, comparatively few of the hundreds of species known are truly detrimental to the interests of mankind. However, the few species that are noxious have given the order a generally bad reputation. Probably most of the known species are feeders on the flowers, leaves and fruits of plants, but others attack the roots, corms and stems. The number of known species which are scavengers, fungivores, carnivores, predators on small arthropods such as aphids, mites and insect eggs is large, and probably a survey would show that the majority of the Pacific species belong to this group. Some species form galls, and especially interesting gall-makers are found in Australia. Some species play a definite part in the pollination of certain plants.

Bailey (1935:856) made a survey of the plant diseases transmitted by thrips. He reported that only two viruses have been clearly demonstrated to be transmitted by thrips, and these are carried by three species of thrips. However, he notes that our knowledge of plant-disease transmission by thrips vectors is at most meager and incomplete. The two diseases mentioned by Bailey are tomato spotted wilt and pineapple yellow spot. Sakimura (1940:281) considers these two diseases to be caused by the same virus. Thrips are also considered to be mechanical vectors of certain bacterial and fungus diseases. Since this was written, Sakimura (1947:57) has published a review of disease transmissions by thrips. He says that spotted wilt is the only virus disease which has been proved to be transmitted by thrips.

The feeding of thrips causes a characteristic type of injury which will be outlined in detail below. New and tender growth is particularly likely to be seriously damaged. The setting of fruit is prevented in some plants when infestation is heavy. Thrips pass copious quantities of liquid feces which dry on the hostplant and cause extensive spotting. When thrips are abundant, parts of the hostplant may become heavily coated with excrement and this may produce an ugly and objectionable discoloration on fruits.

There have been many opinions advanced, and many controversies have arisen, concerning the method of feeding of the Thysanoptera. Some of these have been summarized by Wardle and Simpson (1927:513) as follows:

Thus the thrips has been stated to puncture the tissues and drain the contents of the cells, causing the cell walls to collapse (Horton, J. R. 1921, re *Scirtothrips citri* Moul.); to pierce the epidermis and rasp away the leaf tissues within (Russell, H. M. 1912, re *Heliothrips rubro-cinctus* Giard.); to rasp the leaf tissues and suck up the sap as it exudes (Bedford, H. W.



1921, re *Heliothrips indicus* Bagn.); to pierce the vegetable tissue with its stylets and suck up the liberated plant juices (Cameron, A. E. and Treherne, R. C. 1918, re *Taeniothrips inconsequens* Uzel).

Wardle and Simpson studied *Thrips tabaci* in detail, and their conclusions (1927: 527) are as follows:

1. Observations and experiments concerning *Thrips tabaci* on cotton and other plants suggest that plant injury from thrip[s] attack is in this case due entirely to premature and excessive defoliation, and is dependent in extent and severity upon the value of the infestation factor, or number of thrip[s] stages per unit area of foliage surface. Differences between plant species, plant varieties and plant individuals as regards susceptibility to injury arise chiefly through variations in thickness of the epidermal cell layer.

2. Leaf injury consists essentially of necrosis of a patch of mesophyll cells lying immediately below a gash in an epidermal cell. Such necrosed patches are scattered and isolated when the infestation factor is low, but are confluent and form extensive rusty areas when the infestation is high. Such areas consist of dead cells of the superficial mesophyll layers; the deeper layers, palisade tissue and epidermal layers remain intact, except for the initial gashes made in epidermal cells. In later stages of leaf injury, such necrosis involves the whole leaf, all the layers become disorganized, and premature shedding occurs. There is no evidence that the insect salivary secretion is toxic.

3. The insect does not puncture or rasp the epidermis but gashes an epidermal cell by pickaxe-like movements of the single mandible, induced by a slight rocking movement of the head. In most cases, the mandible can only gash the outer epidermal wall, the inner wall and the lateral walls of the mesophyll cells being broken down by similar movements of the longer protruded maxillary laciniae. There is no evidence of attack through the stomata. Suction of the chloroplasts into the pharynx is aided probably by the partial vacuum established within the mouth cone when applied closely to the leaf surface.

4. The preference shown by thrip[s] stages for the lower surface of leaves is believed to be due rather to differences in thickness of epidermis between the lower surface and the upper surface, than to negative phototropism. In plants where such differences are slight, such as cotton plants, thrip[s] stages readily invade the upper leaf surface. On *Cajanus indicus*, the upper surface is the more favoured, the lower surface being unsuitable owing to the close spacing of numerous fine hairs. The more widely spaced hairs on cotton leaves do not act as a deterrent, the hairy American and Indian varieties being more heavily attacked than the smoother leaved Egyptian varieties of cotton.

However, Hinds (1902:117) stated that at least some species would move to the dark side of a leaf if it were turned over so as to expose the thrips to direct light. Additional notes on feeding are given under *Thrips tabaci* in this text.

Field workers and agriculturists are frequently bitten by thrips, especially in areas of heavy infestation. Some Thysanoptera will actually feed on man by puncturing the skin and sucking blood. I have been bitten by thrips on a number of occasions, but only a slight, sharp, pricking sensation was noted. Some people have reported swellings, itching and a "pinkish dotting" of the skin at the site of the bites. Bailey (1936:95-98) gives a good summary of thrips attacking man, and his report includes a bibliography.

There are a number of insect enemies of thrips. Among the predators are *Orius* and related anthocorid bugs, chrysopid lacewings, syrphid fly larvae and coccinellid beetles. *Orius persequens* is a common predator in Hawaii. Illing-

worth (1931:879) reported that the abundant cucujid beetle, *Cryptamorphus desjardinsi*, was a thrips predator both in the larval and adult stages. In Hawaii, the immigrant, minute, remarkable, fringe-winged, trichogrammatid wasp, *Megaphragma mymaripenne* Timberlake (Timberlake, 1924:414), attacks the eggs of some species, including *Heliothrips haemorrhoidalis*. Two species of small, tetrastichine, chalcid wasp parasites of larvae have been imported. One, *Thripoctenus russelli* Crawford (see Russell, 1912:1), has been purposely brought in from California, and the other, *Thripoctenus brui* Vuillet, was introduced from Japan to prey upon *Thrips tabaci*. These last two parasites lay their eggs in the bodies of the larval thrips, and the parasites subsequently destroy their hosts. In addition to insect enemies, certain nematode worms, fungi, mites and spiders are known to attack thrips.

As noted above, the Terrebrantia are generally not tolerant of wet, rainy conditions, and inasmuch as our principal crop-pest thrips belong to this suborder, heavy rains are a decided aid in reducing and keeping down thrips populations. The worst thrips damage can be expected to occur in the drier, hotter regions of our islands.

The artificial control of thrips consists principally of dusting and spraying. Nicotine dusts and sprays have been long used successfully, and tartar emetic-sugar-water sprays are gaining favor among many growers. Further information on control is given under the species headings.

The Thysanoptera are largely in a state of taxonomic chaos, and the group is a most difficult one to work with systematically. There is not yet available a classification which can be considered adequate or natural. The basic concept of what constitutes the various categories of classification appears more often than not to have been lost sight of. Few authorities agree as to what constitutes a genus, subfamily, family or superfamily. Speyer (1934:150-151) expressed his opinion as follows:

At least amongst the Thysanoptera, the ever-growing confusion is due to meagreness of description for the generic character. However true the contention that the genus is a group of somewhat similar species, assembled together for the sake of convenience rather than philogenetic affinity, there is no justification for a system of classification based upon structures of the insect which happen conveniently to strike the eye, with no primary inquiry into the possibility of such structures being highly variable in the species. The scientific examination of structure has of late given way to short-cut methods of mechanical measurement, relating to portions of the external anatomy for which no attempt at proof of constancy in the species has been undertaken.... The confusion that has arisen can be unravelled only by reference to the *type species* of such genera as have already been raised, for these are the only definitely fixed points which are available to the systematist.

In not a few cases the actual type specimen representing the genus may not be available, or is in a state of preservation which defies examination, but in the majority of cases the type of the genus is represented by a species not only well recognised, but of which fresh material can without difficulty be obtained. There is now occasion for the systematist to determine from series of specimens what characters are liable to most and what characters to least variation in the type species of each genus, and from the latter category and from a similar examination of related species to choose constant characters which are serviceable for the separation of species within the genus. Only after such an undertaking is complete

will it be possible to raise genera and higher groups for the final constitution of a justifiable classification, of practical value for the systematist and satisfactory to the needs of the biologist.

Newly emerged individuals differ, as other insects do, from fully matured individuals. Yet new forms are described from teneral specimens. One author placed specimens of one species in two different genera, because one lot was col-

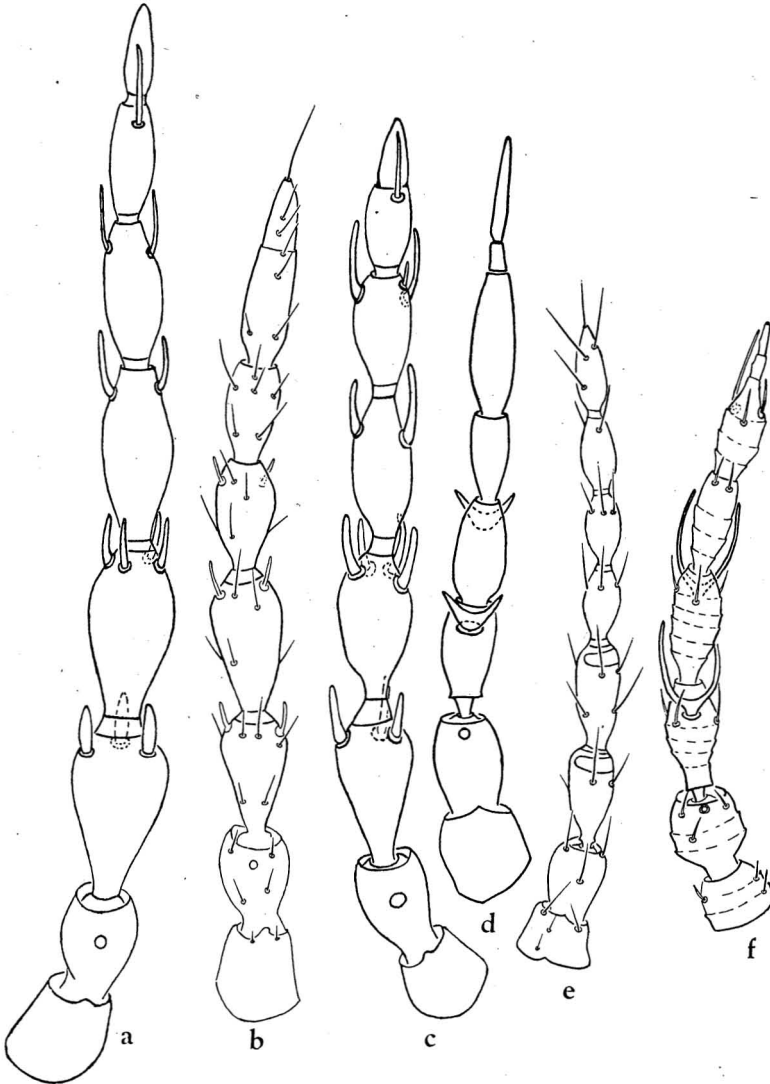


Figure 216—Sketches of the antennae of some thrips. **a**, *Phlaeothrips claratibia* Moulton; **b**, *Hoplothrips flavipes* (Bagnall); **c**, *Hoplothrips mauensis* Moulton, paratype male; **d**, *Docidothrips trespinus* (Moulton), female, right dorsal; **e**, *Merothrips hawaiiensis* Moulton, female, right dorsal; **f**, *Dendrothripoides ipomeae* Bagnall, female, right dorsal. (Kindly drawn for this chapter by F. A. Bianchi.)

lected in a cyanide bottle and allowed to dry up before being placed in alcohol, whereas the other lot from the same plant was placed directly from the hostplant into alcohol. The proportions of the heads of the dried specimens differed from the measurements of the examples preserved in fluid. For a discussion of the confusing variability in a single species, see the discussion under *Taeniothrips hawaiiensis* farther along in this section.

In the following text, I have attempted to follow the classification and methods of distinguishing the various groups that are in current use, but I have not always been successful. I feel that much work remains to be done before even our small thysanopterous fauna is satisfactorily arranged taxonomically, and I know that the following text needs much revision. However, it has been my purpose to try to present materials which will enable the struggling worker to identify his collections of Hawaiian specimens.

I am indebted to Dr. Frederick Laing for sending notes on the Bagnall types in the British Museum which are incorporated herein.

TABULAR ANALYSIS OF THE HAWAIIAN THYSANOPTERA

FAMILY	GENERA	ENDEMIC GENERA	NON- ENDEMIC GENERA	SPECIES	ENDEMIC SPECIES	ADVENTIVE SPECIES
Aeolothripidae	1	0	1	1	0	1
Thripidae	20	0	20	46	7(?)	39
Phlaeothripidae	14	1(?)	13	39	14+6(?)	15+4(?)
Urothripidae	2	1	1	2	1	1
Totals	37	2(?)	35	88	28(?)	60(?)

Percentage of endemism in native group: genera, 33.3 percent (?); species, 100 percent.

Percentage of present-day fauna native: 31.5 percent.

Percentage of present-day fauna adventive: 68.1 percent.

Average number of species per genus in native group: 4.6.

Average number of species per genus in adventive group: 1.7.

These figures will be subject to change when our thrips fauna has been revised and studied in detail. The status of a number of the species is uncertain.

#### KEY TO THE SUBORDERS

1. Wings with well-developed veins, fore pair with a marginal vein and at least one longitudinal vein that reaches apex; wing membrane with microscopical hairs; terminal abdominal segment sub-conical in female, broadly rounded in male, never tubular; ovipositor present and saw-like. . . . . **Terrebrantia.**
2. Wings with greatly reduced venation, fore pair with at most only a median longitudinal vein that does not reach the wing apex; wing membrane without minute hairs; terminal abdominal segment tubular in both sexes, often conspicuously elongate; ovipositor absent . . . . . **Tubulifera.**

## Suborder TERREBRANTIA Haliday, 1836

This suborder contains the more important crop-pest thrips. Its members are mostly more active than those of the Tubulifera and generally have less cryptic habits. Many species are found on flowers and many are active runners and/or jumpers.

The apex of the abdomen of the females is usually pointed and sub-cone-shaped, whereas it is usually bluntly rounded in the males. The ovipositor is normally well developed. It has four valves, is saw-like, and usually lies partially or completely concealed in a sheath in the three terminal ventrites when at rest.

### KEY TO THE SUPERFAMILIES OF TERREBRANTIA

1. Wings comparatively broad, apices rounded; antennae nine-segmented; ovipositor curved upward; body not depressed ..... **Aeolothripoidea.**
2. Wings comparatively narrow, apices usually pointed; antennae six- to eight-segmented; ovipositor curved downward; body somewhat depressed ..... **Thripoida.**

### Superfamily AEOLOTHRIPOIDEA Hood, 1915

This superfamily contains only one family, and it includes the most primitive of the known living Thysanoptera.

#### Family AEOLOTHRIPIDAE Uzel, 1895

Antennae nine-segmented, either freely movable or with the apical joints connate; intermediate segments usually cylindrical, without specialised chaetotaxy, but uniformly clothed with short setae. No sense-cones present; membranous, longitudinally elongated sensory areas on segments three and four, and smaller areas on certain other segments. Maxillary palpi geniculate, 3-8 segmented; labial palpi 2-5 segmented. Wings, when present, large, broad and rounded apically; forewing with a heavy ring-vein [the ambient or marginal vein] and two longitudinal veins reaching from base to tip and each uniting with the ring-vein before tip; cross veins usually present; front margin of forewings without, or with only a light fringe of hairs. Legs long. Ovipositor curved backwards. (Bagnall, 1913:394.)

#### Subfamily AEOLOTHRIPINAE Bagnall, 1913:396

##### The Broad-Winged Thrips

#### Genus AEOLOTHRIPS Haliday, 1836:451

**Aeolothrips fasciatus** (Linnaeus) (fig. 217, a).

*Thrips fasciata* Linnaeus, 1758:457; 1761:267.

For detailed description and illustrations, see Hinds, 1902:127-130. For synonymy and description, see Priesner, 1928:105.

Genotype of *Aeolothrips*.

The striped or banded thrips; the six-spotted thrips.

Oahu, Maui, Hawaii.

Immigrant. Cosmopolitan. First found in the Hawaiian Islands by Swezey on *Styphelia* (*Cyathodes*) *tameiameiae* on Mount Haleakala, Maui, in 1927.

This species; whose fore wings have a pale cross band at base, middle and apex, with broader dark brown bands between the white bands, can be expected to be found on many plants. It preys upon other thrips, aphids, mites, etc., and it spins a cocoon in which to pupate.

## Superfamily THRIPOIDEA Hood, 1915:57

Several families are recognized in this division, but representatives of only one are known to occur in Hawaii.

### Family THRIPIDAE Uzel, 1895

The members of this family have from six to eight segmented antennae...the segments beyond the sixth are usually short and form what is called the style. Maxillary palpi are usually three, sometimes two segmented; labial palpi never composed of more than two segments. The wings of Thripidae are usually slender, gradually tapering more or less and pointed at the tips. The fore wings, as a rule, present two parallel longitudinal veins, the front one running from the base to near the tip of the wing; the hind vein appears usually as a branch from the fore vein at about one-third the length of the wing. Sometimes, however, all connection between these veins is wanting. Cross veins are rarely visible, though traces of them can sometimes be seen. The ring vein is not usually very heavy or prominent. A fringe is generally present upon the front margin of the fore wing, but may be vestigial. More or less stout spines are found along the veins and costa of the fore wing. The hind wing has one median, longitudinal vein without spines and no cross or ring veins, but the costa bears a fringe. The ovipositor of the female is bent downward, i.e., concave side ventral. (Hinds, 1902:132.)

### KEY TO THE SUBFAMILIES FOUND IN HAWAII

1. Antennae inserted on a triangular process which is drawn out in front of eyes; males apterous, females winged. . . . . **Chirothripinae.**  
 Front of head not so produced; sexes usually, but not always, similar . . . . . 2
- 2(1). Derm, especially of head and prothorax, with conspicuous, deep, coarse, polygonal, reticulate sculpture. . . . . **Heliothripinae.**  
 Derm not so sculptured (at most with partially confluent, transverse wrinkles forming a fine reticulation) . . . . . 3
- 3(2). Fore wings with only one longitudinal vein (but compare Thripinae); prothorax for the most part without long spines . . . . . **Sericothripinae.**

Fore wings with two or more longitudinal veins (except in *Leucothrips* in which the two longitudinal veins in fore wings are fused from near base to apex); at least the hind angles of prothorax with rather long spines (except in *Anaphothrips*) ..... **Thripinae.**

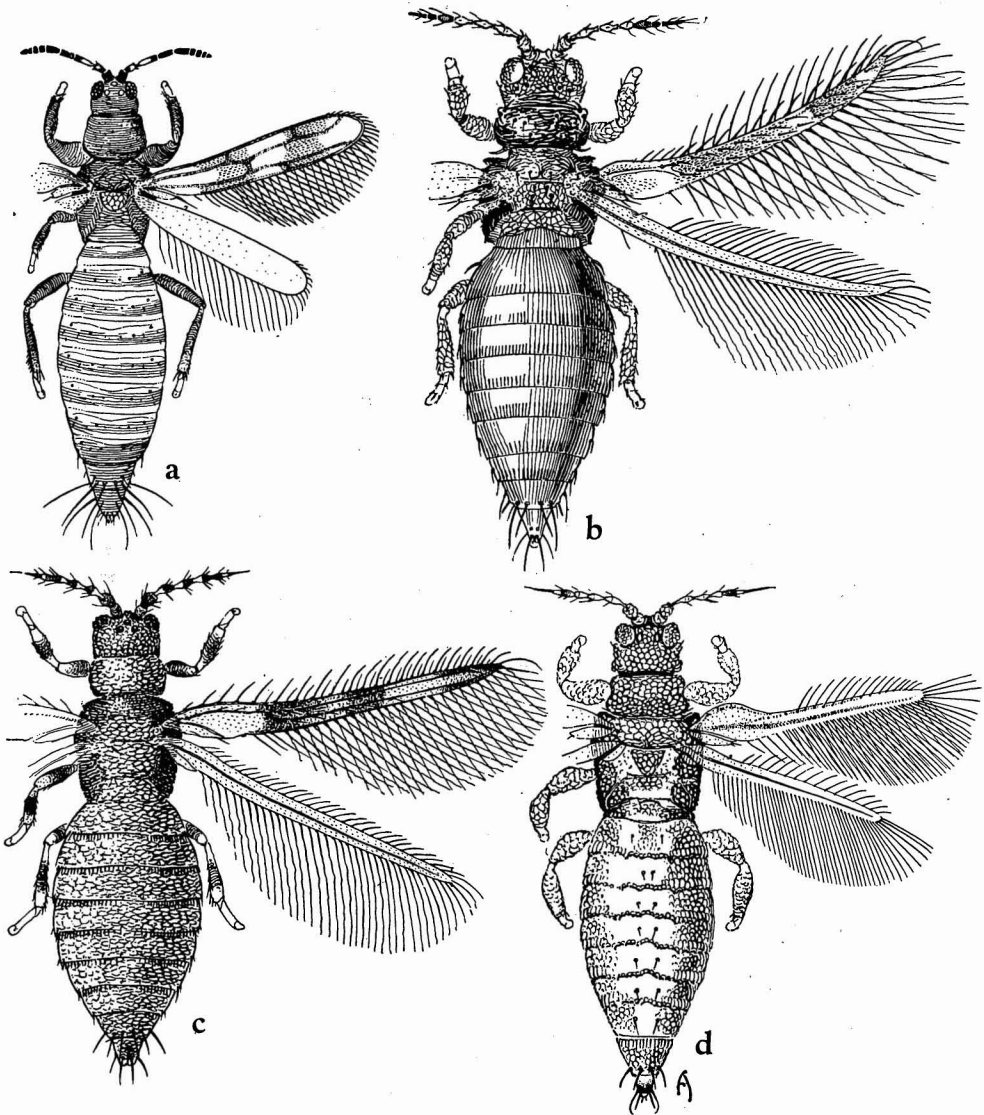


Figure 217—**a**, *Aeolothrips fasciatus* (Linnaeus); **b**, *Hercinothrips femoralis* (Reuter); **c**, *Hercotothrips fasciatus* (Pergande); **d**, *Heliothrips haemorrhoidalis* (Bouché). (Abernathy drawings; not to same scale.)

## Subfamily HELIOTHRIPINAE Karny, 1921

## KEY TO THE GENERA FOUND IN HAWAII

1. Head with a collar near hind margin in front of basal constriction, showing as a dentiform process at either side at postero-lateral angles (the collar may be difficult to see, but the processes are distinct) ..... **Hercinothrips** Bagnall.  
Head without such a collar or processes..... 2
2. Antennal segments three and four stem-like at either end and with forked trichomes; hind coxae less than one-third as widely separated as breadth of a coxa..... **Hercothrips** Hood.  
Antennal segments three and four not stem-like at the distal ends and without trichomes; hind coxae fully one-half as widely separated as breadth of a coxa..... **Heliothrips** Haliday.

Genus **HERCINOTHRIPS** Bagnall, 1932:506**Hercinothrips femoralis** (Reuter) (fig. 217, b).*Heliothrips femoralis* Reuter, 1891:166.*Hercinothrips femoralis* (Reuter) Bagnall, 1932:506.

Redescribed and figured by Hinds, 1902:172, pl. 5, figs. 55-56; pl. 6, fig. 57.

For synonymy see Priesner, 1928:130.

The banded greenhouse thrips.

Kauai, Oahu, Maui, Hawaii.

Immigrant. A widespread species. First recorded from the Hawaiian Islands by Moulton (1934:499) from specimens collected by Sakimura in Honolulu.

Hostplants: banana (causes "silver and bronze scars" which may result in damage of some economic importance), beet, celery, *Commelina diffusa* (nudi-flora), *Crinum*, *Chrysanthemum*, dwarf milo maize, eggplant, *Emilia sonchifolia* (flammea), *Erechtites hieracifolia*, grass, orchids, pineapple, *Plantago major*, *Sonchus oleraceus* ("pualele," sow thistle), sugarcane, tomato.

For a list of hostplants in America see Eide, 1943:327. For notes on damage done to bananas, see Bianchi, Proc. Hawaiian Ent. Soc. 12(3):481, 1946.

Control: nicotine sulphate in 1:400 to 600 dilution has been recommended for use on orchids.

Genus **HERCOTHRIPS** Hood, 1927:233**Hercothrips fasciatus** (Pergande) (fig. 217, c).*Heliothrips fasciata* Pergande, 1895:391.*Hercothrips fasciatus* (Pergande) Hood, 1927:233.

See Bailey (1933) for bionomics (in California), for detailed descriptions of all stages, illustrations, bibliography, etc.



The bean thrips.

Oahu, Molokai, Hawaii.

Immigrant. Widespread. First found in the Hawaiian Islands by Krauss at Kaunakakai, Molokai, in June, 1943, and by Bianchi on Hawaii in June, 1945, and Oahu in April, 1946.

Hostplants: *Argemone alba* var. *glauca* (leaves, flowers, buds), *Sonchus oleraceus*. (Possible hosts which may be attacked in Hawaii include alfalfa, avocado, bean, beet, cabbage, cauliflower, corn, cotton, grape, lettuce, nasturtium, onion, citrus, pea, potato, radish, Swiss chard, tomato, turnip, *Amaranthus*, *Bidens*, *Cassia*, *Erigeron* and *Nicotiana glauca*.)

This species has become established in Hawaii so recently that no survey of its habits has been made here. However, it is a serious pest elsewhere, and it is most unfortunate that it has established itself in Hawaii. Essig (1929:183) says that it "is a general feeder on leguminous plants, truck, field and forage crops, grasses, deciduous and citrus fruit trees, and so forth, and is a serious pest to beans and cotton in California and Arizona, and to the fruits of oranges, avocados and olives in California." It is an important pest to commercial crops in the dry and non-irrigated parts of California. The species was originally described from Yuba County, California.

The females can reproduce parthenogenetically, but in doing so are capable of giving rise only to males. Females can only be produced by fertilized females.

This species is an active jumper—being capable of leaping about a foot—but it is not a strong flyer. Pupation takes place in the soil.

Parasite: *Thripoctenus russelli* Crawford (Hymenoptera: Eulophidae).

### Genus **HELIOTHRIPS** Haliday, 1836:443

**Heliothrips haemorrhoidalis** (Bouché) (fig. 217, d).

*Thrips haemorrhoidalis* Bouché, 1833:206.

*Heliothrips Adonidum* Haliday, 1836:443. Genotype.

For detailed synonymy and description, see Hinds, 1902:168, and Priesner, 1928:126.

The greenhouse thrips.

Kauai, Oahu, Molokai, Maui, Hawaii.

Immigrant. Almost cosmopolitan. First recorded from Hawaii by Bagnall (1910:698) from specimens collected by Perkins.

Hostplants: boysenberry, *Clermontia parviflora*, croton, *Eucalyptus* (damaging young leaves), *Fuchsia*, *Gladiolus*, *Hibiscadelphus giffardianus* (found damaging seriously the last known example of this nearly extinct native tree), *Hibiscus*, *Hypochoeris radicata*, *Metrosideros*, peach, *Rubus penetrans*, *Vaccinium calycinum*.

Probably also on: *Araucaria*, avocado, azalea, bignonia, citrus, fig, guava, *Pelea*, *Rhododendron*, rose, *Styphelia*.

Parasite: *Megaphragma mymaripenne* Timberlake (1924:414, fig. 7) (Hymenoptera: Trichogrammatidae) on the eggs (the exit holes, 0.08–0.09 mm. in diameter, may be seen in the swellings in the leaves over the thrips eggs).

The greenhouse thrips has been the cause of considerable injury to ornamentals during the past century, and where its presence is not suspected or treatment is neglected it will cause the utter ruin of certain plants, in the greenhouse, grown principally for the beauty of their foliage. Likewise in the more tropical sections of the United States, such as southern Florida and southern California, this insect causes great damage to some outdoor plants. (Russell, 1912:1.)

No detailed studies have been made on this species in Hawaii, although it has been here for many years. The feeding punctures appear to be confined largely to the foliage, with the fruits of some kinds of plants similarly attacked. Russell (1912) found the egg stage to be of about eight days' duration, the larval period 10 to 20 days, and the prepupal–pupal periods four to six days. The entire life cycle may take from three weeks to one month. Only females of this species are known, and all reproduction is parthenogenetic. The larvae pupate on the host.

The foliage and fruits of attacked plants become heavily spotted with excrement and may become conspicuously discolored.

Control: tartar emetic–sugar–water sprays have been recommended.

Wittwer and Haseman (1946:331) noted in their experiments that New Zealand spinach grown with a high nitrogen supply was almost immune to attack, whereas plants grown with a low nitrogen supply were heavily attacked.

#### Subfamily SERICOTHRIPINAE Karny, 1921

##### KEY TO THE GENERA FOUND IN HAWAII

1. Maxillary palpi two-segmented; fore wings very narrow, veins obsolete ..... **Dendrothripoides** Bagnall.  
Maxillary palpi three-segmented; fore wing veins distinct..... 2
2. Eyes comparatively prominent and protruding; antennal segments five and six closely joined, six sub-cone-shaped.....  
..... **Scirtothrips** Shull.  
Eyes not prominent, not protruding; antennal segments five and six not closely joined, six sub-spindle-shaped.....  
..... **Anaphothrips** Uzel.

#### Genus **DENDROTHRIPOIDES** Bagnall, 1923:624

**Dendrothripoides ipomeae** Bagnall (figs. 216, f; 218).

*Dendrothripoides ipomeae* Bagnall, 1923:625. Genotype.

Kaūai, Oahu.

Immigrant. Almost cosmopolitan; described from India. First found in Hawaii at Kailua, Oahu, by Bianchi in 1941.

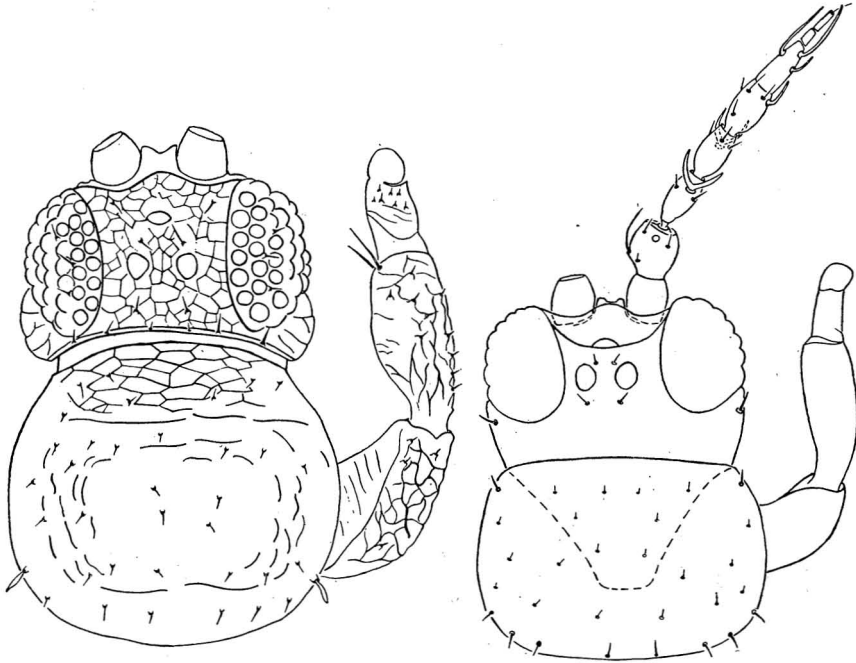


Figure 218—Details of two thrips: *Dendrothripoides ipomeae* Bagnall, left; *Scirtothrips antennatus* Moulton, right. (Kindly drawn for this text by F. A. Bianchi.)

Hostplants: *Echinochloa crus-galli*, *Dioscorea*, *Ipomoea congesta*, lettuce, sweet potato.

Although this species has been reported to cause damage to sweet potatoes here and abroad, Bianchi (who found the eggs inserted just under the surface of tender new shoots) reported in 1942 that he found no damage to sweet potatoes, but, on the contrary, there appeared to be some indication that the species was preying on the eggs of the leaf miner *Bedellia orchilella* Walsingham. However, Sakimura and Nishida (1944:125) record definite damage to sweet potato and lettuce, and Look and Nishida (Proc. Hawaiian Ent. Soc. 12[2]:216, 1945) report severe damage to sweet potatoes. "The injured leaves are scarred and crinkled by the thrips which breed in the young shoots. This injury is easily confused with that of the broad mite, *Hemitarsonemus latus* (Banks)."

#### Genus **SCIRTOTHRIPS** Shull, 1909

***Scirtothrips antennatus*** Moulton (fig. 218).

*Scirtothrips antennatus* Moulton, 1937:409.

Kauai, Oahu (type locality: Honolulu), Hawaii.

Immigrant from North America.

Hostplants: burdock, *Colubrina oppositifolia*, carrot, cowpea, *Nothopanax*, parsley, *Passiflora*, *Plumeria*.

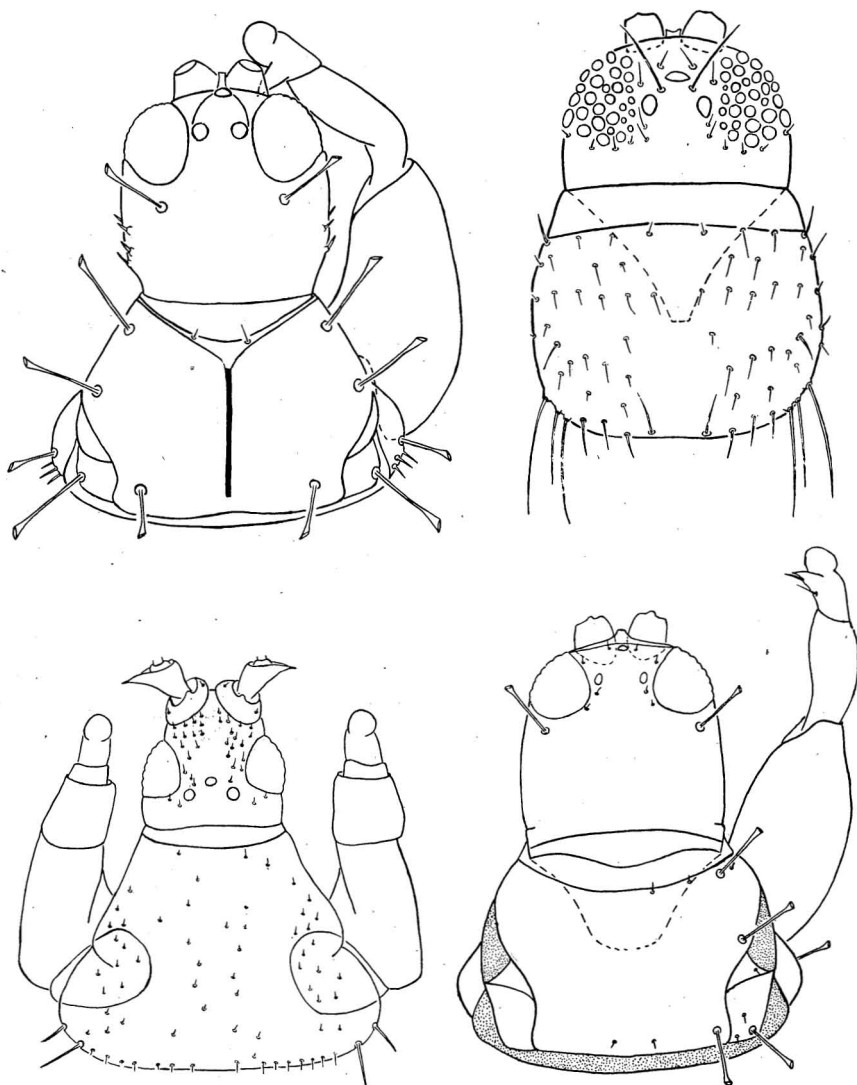


Figure 219—Details of some thrips. Top left, *Phlaeothrips mauensis* Moulton, paratype male, minor setae omitted; top right, *Docidothrips trespinus* (Moulton); bottom left, *Chirothrips fulvus* Moulton; bottom right, *Hoplothrips flavipes* (Bagnall). (Kindly drawn for this work by F. A. Bianchi.)

### Genus **ANAPHOTHRIPS** Uzel, 1895:142

#### KEY TO THE SUBGENERA

1. Prothorax without long bristles on hind margin; sixth antennal segment less than three times as long as broad in our species; fore wings not banded . . . . . **Anaphothrips** Uzel.
2. Hind margin of prothorax with long bristles; sixth antennal segment more than three times as long as broad in our species; fore wings with two dark bands . . . **Chaetanaphothrips** Priesner.

Subgenus *Chaetanaphothrips* Priesner, 1924:145; 1928:204

**Anaphothrips** (*Chaetanaphothrips*) *orchidii* (Moulton) (fig. 220, a).

*Euthrips orchidii* Moulton, 1907:52, pl. 2, fig. 15-18.

*Anaphothrips* (*Chaetanaphothrips*) *orchidii* (Moulton) Priesner, 1924:145; 1928:204. Type of subgenus.

Kauai, Oahu, Hawaii.

Immigrant. Widespread. First recorded from the Hawaiian Islands by Moul-

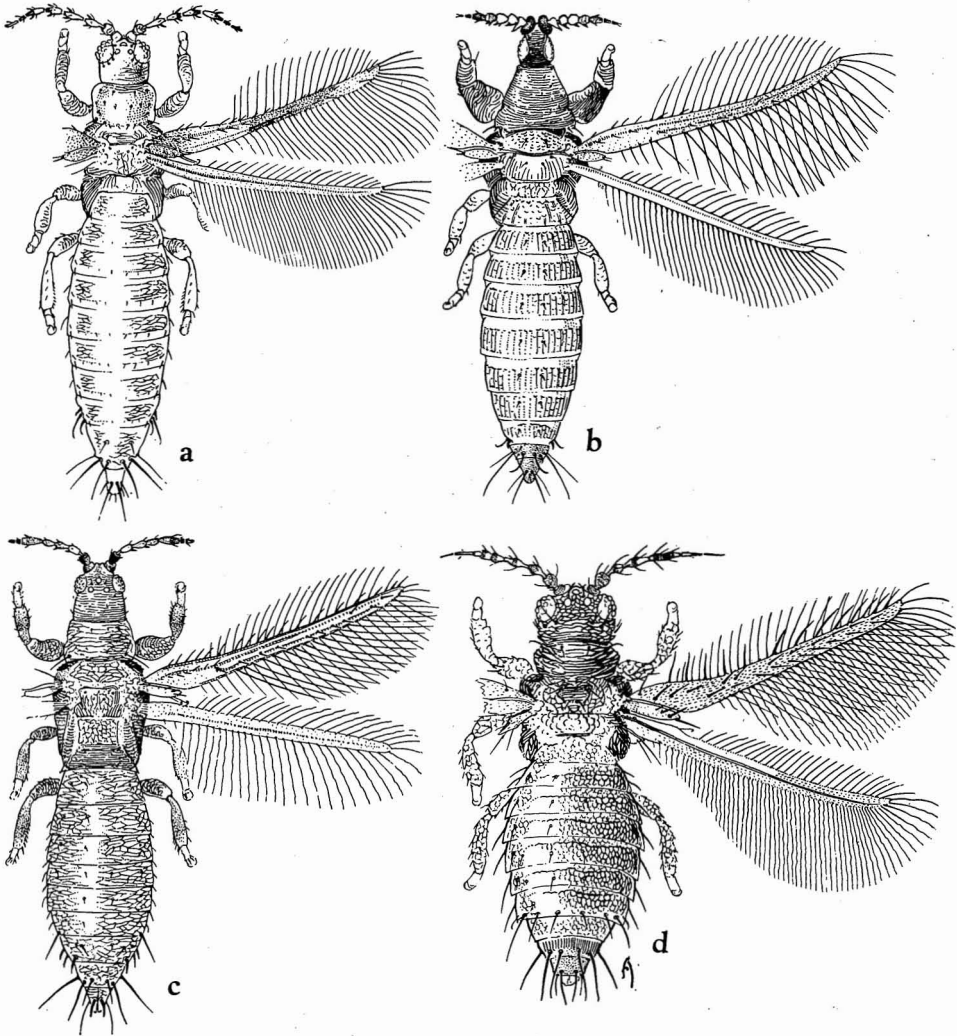


Figure 220—*a*, *Anaphothrips orchidii* (Moulton); *b*, *Chirothrips mexicanus* Crawford; *c*, *Limothrips cerealium* (Haliday); *d*, *Selenothrips rubrocinctus* (Giard). (Abernathy drawings; not to same scale.)

ton (1928:107) from a specimen collected by Williams from *Commelina diffusa* (*nudiflora*) on Mount Tantalus, Oahu.

Hostplants: *Anthurium*, *Bougainvillea*, *Commelina diffusa* (*nudiflora*), *Emilia sonchifolia*, grass, *Heimerliodendron brunonianum*, *Litchi*, orchids (with occasional heavy infestations reported), parsley, sweet potato.

Takahashi (1936:430) reports that this species rolls the edges of young leaves of a species of *Machilus* in Formosa. It is a parthenogenetic form, and no males have been found in Hawaii. Sakimura has found that a complete life cycle on *Emilia sonchifolia* takes less than 33 days in the winter months in Hawaii.

### Subgenus *Anaphothrips* Uzel

#### KEY TO THE SPECIES KNOWN TO OCCUR IN HAWAII

1. Dark-brown species ..... **secticornis** (Trybom).  
Pale-yellow species ..... 2
2. Spines on dorsal apical margin of precaudal (ninth) abdominal tergite dark, heavy, stiff ..... **obscurus** (Müller).  
Spines on dorsal apical margin of ninth tergite pale, thin, slender ..... **swezeyi** Moulton.

#### *Anaphothrips* (*Anaphothrips*) **obscurus** (Müller).

*Thrips obscurus* Müller, Zool. Dan. Prodrum, p. 96, 1776 (I have not seen this reference).

*Anaphothrips* (*Anaphothrips*) *obscurus* (Müller), Priesner, 1928:183.

Oahu, Maui.

Immigrant. Nearly cosmopolitan. First found in the Hawaiian Islands in 1944 by Bianchi in a greenhouse at Honolulu (1945:282).

Hostplants: Sudan grass, sugarcane.

"On Sudan grass the damage appeared in the usual 'silvering' of the leaves while on young cane the edges of the leaves become red or reddish in longitudinal areas and partly curled back upon themselves." (Bianchi, 1945:283.) This is a grass pest species elsewhere.

#### *Anaphothrips* (*Anaphothrips*) **secticornis** (Trybom).

*Thrips secticornis* Trybom, Öfv. Vet. Akad. Förh. 8(8):620, 1896 (I have not seen this publication).

*Anaphothrips* (*Anaphothrips*) *secticornis* (Trybom), Priesner, 1928:189, fig. 42.

Hawaii.

Immigrant. A widespread Holarctic species. First found at Kilauea, Hawaii, by Bianchi in 1944 (1945:282).

Hostplant: barley (?).

**Anaphothrips (Anaphothrips) swezeyi** Moulton.

*Anaphothrips (Anaphothrips) swezeyi* Moulton, 1928:107.

Kauai, Oahu (type locality: Honolulu), Hawaii.

Immigrant, but not yet recorded elsewhere.

Hostplants: a common grass thrips; *Cenchrus echinatus*, *Digitaria sanguinalis* (*Syntherisma sanguinalis*), *Echinochloa crus-galli*, *Panicum purpurascens* (barbinode), *Panicum torridum*, *Setaria geniculata* (*Chaetochloa geniculata*), *Setaria verticillata* (*Chaetochloa verticillata*), sugarcane, *Tricholaena repens* (rosea), *Trisetum glomeratum*.

This species appears to be closely similar to *obscurus*, and the differences between it and *obscurus* are hard to describe. Perhaps it is not a distinct species.

Subfamily CHIROTHRIPINAE Karny, 1921

KEY TO THE GENERA FOUND IN HAWAII

1. Prothorax almost twice as long as head; second antennal segment remarkably expanded on outer side... **Chirothrips** (Haliday).  
Prothorax not much longer than head; second antennal segments not so formed ..... 2
2. Antennae six-segmented ..... **Aptinothrips** Haliday.  
Antennae eight-segmented ..... **Limothrips** (Haliday).

Genus **CHIROTHRIPS** (Haliday)

*Thrips*, subgenus *Chirothrips* Haliday, 1836:444.

The males of all the species are apterous.

KEY TO THE SPECIES FOUND IN HAWAII

1. Basal abdominal tergites with subbasal serration or lobes; forehead with two pairs of setae on each side between anterior ocelli and base of antennae, and a seta on each side between anterior ocelli and base of antennae and a seta on either side of anterior ocellus..... **mexicanus** Crawford.  
Basal abdominal tergites not serrate; forehead with four or more setae anterior to fore ocellus..... 2
2. Forehead with about four to eight setae on each side, none opposite anterior ocellus..... **spiniceps** Hood.  
Forehead with about 15 to 17 setae on each side, with one on each side of anterior ocellus..... **fulvus** Moulton.

**Chirothrips fulvus** Moulton (fig. 219).

*Chirothrips fulvus* Moulton, 1936:182.

Kauai, Oahu (type locality: Paumalu), Hawaii.

Immigrant; also known from Texas (material in Moulton collection).

Hostplants: *Paspalum orbiculare*, *Paspalum dilatatum* (Dallas grass).

"This species is distinguished by having fifteen to seventeen forehead setae [on each side, that is] and the ocellar pair placed opposite anterior ocellus, by the enlarged first antennal segments, fore wings with light bands also the fore vein of fore wing has four spines near base and two near tip; the hind vein has five rather regularly placed spines." (Moulton, 1936:183.)

**Chirothrips mexicanus** Crawford (fig. 220, b).

*Chirothrips mexicanus* Crawford, 1909:114, fig. 51.

Moulton, 1928:106, describes the male.

Kauai, Oahu, Maui, Hawaii, Midway.

Immigrant. Known from North and South America and the Philippines. First recorded from the Hawaiian Islands by Moulton (1928:106) from specimens collected on Oahu by Swezey in 1927. Described from tobacco flowers from Guadalajara, Mexico.

Hostplants: *Ammophila arenaria*, *Chloris inflata* (*paraguayensis*), *Eragrostis variabilis*, *Panicum purpurascens*, *Setaria geniculata*, sugarcane.

This species has only two pairs of forehead setae on each side and one seta at either side of the anterior ocellus; there is one longitudinal vein in the fore wing, the first antennal segment is deep brown; there is a pair of heavier and distinctly differentiated spines on the postero-lateral prothoracic angles, and the basal abdominal tergites are subbasally serrate.

Bianchi (1941:37) reported finding the species in large colonies on *Eragrostis variabilis* and *Ammophila arenaria* on Midway Island.

**Chirothrips spiniceps** Hood.

*Chirothrips spiniceps* Hood, 1915:12, pl. 1, fig. 8.

*Chirothrips sacchari* Moulton, 1936:181. Synonymy by Hood, 1939:464.

Kauai, Oahu.

Immigrant. A widespread North American species. First recorded from the Hawaiian Islands by Moulton (1936:181) from specimens collected at Kailua, Oahu, by Swezey.

Hostplants: corn, *Setaria geniculata*, *Echinochloa crus-galli* (barnyard grass), sugarcane.

This species has four to eight forehead setae on each side; two longitudinal wing veins; the first antennal segment is yellow or slightly infuscated and the pair of spines on the postero-lateral corners of the prothorax is not strongly differentiated from its neighbors. It has not caused any particular damage in Hawaii, although it is at times quite abundant locally.



Genus **APTINOTHRIPS** Haliday, 1836

**Aptinothrips rufa** (Gmelin).

*Thrips rufa* Gmelin, in Linnaeus, 1788:2224.

Maui, Hawaii.

Immigrant. A widespread species described from Europe. First found in the Territory by Bianchi at Kilauea, Hawaii, in 1944 (1945:282).

Hostplants: barley (?), "grass," *Holcus lanatus*.

Genus **LIMOTHRIPS** (Haliday)

*Thrips*, subgenus *Limothrips* Haliday, 1836:444.

**Limothrips cerealium** (Haliday) (fig. 220, c).

*Thrips (Limothrips) cerealium* Haliday, 1836:445.

*Limothrips avenae* Hinds, 1902:139, pl. 1, figs. 10-12; pl. 2, fig. 13.

The cereal or corn thrips.

Kauai, Oahu, Hawaii.

Immigrant. Cosmopolitan. First recorded from the Hawaiian Islands by Bagnall (1910:701) from specimens collected by Perkins in 1892 and 1897.

Hostplants: various grasses.

Hinds (1902:139) gives a detailed, illustrated description of this species. The males are apterous.

Subfamily **THRIPINAE** Karny, 1921

This subfamily contains most of the thrips of economic importance.

KEY TO THE GENERA FOUND IN HAWAII

1. Antennae thread-like, eight-segmented, without a terminal style; pronotum with longitudinal dorsal sutures; fore and hind femora conspicuously swollen.... **Merothrips** Hood.
- Antennae not thread-like, six- to eight-segmented with a terminal one- or two-segmented style; pronotum without longitudinal dorsal sutures; fore and hind femora not swollen ..... 2
- 2(1). Derm with numerous, confluent, sculpture ridges forming a fine reticulation ..... **Selenothrips** (Karny).
- Derm not so reticulated..... 3
- 3(2). Antero-lateral prothoracic angles armed with one or more long, strong bristles ..... 4
- Antero-lateral prothoracic angles not so armed..... 5
- 4(3). Lateral margins of prothorax each with a comparatively long bristle at middle; interocellar bristles as long as or longer than head; wings with dark maculae.....
- ..... **Scolothrips** Hinds.

- Lateral prothoracic margins without such bristles; inter-  
 ocellar bristles shorter than head; wings pale.....  
 .....**Frankliniella** Karny.
- 5(3). Maxillary palpi two-segmented ..... 6  
 Maxillary palpi three-segmented ..... 7
- 6(5). Head conspicuously produced beyond eyes; eyes distant  
 from fore margin of head.....**Organothrips** Hood.  
 Eyes anterior, their fore margins about on a level with  
 anterior edge of front of head.....**Leucothrips** Reuter.
- 7(5). Antennae seven-segmented ..... 8  
 Antennae eight-segmented ..... 9
- 8(7). Postero-lateral angles of prothorax with three prominent  
 bristles .....**Docidothrips** Priesner.  
 Postero-lateral angles of prothorax with two prominent  
 bristles .....10
- 9(7). Antennal sense trichomes simple.....**Bregmatothrips** Hood.  
 Antennal sense trichomes forked.....  
 .....**Taeniothrips** Amyot and Serville.
- 10(8). Anterior ocellus placed anterior to fore margins of eyes;  
 fourth antennal segment elongate; ovipositor reduced;  
 males with a pair of heavily sclerotized, finger-like proc-  
 esses on posterior margin of ninth abdominal tergite..  
 .....**Plesiothrips** Hood.  
 Not so .....**Thrips** Linnaeus.

#### Genus **MEROTHRIPS** Hood, 1912:132

Two species of this genus have been recorded in our literature. However, there is some reason to believe that only one species is involved. *Merothrips morgani* is the name assigned to a form whose colonies have been found to consist entirely of wingless individuals both in Hawaii and in North America. Our *Merothrips hawaiiensis*, however, is known only from winged forms. It is of interest that the only known specimens of *Merothrips hawaiiensis* were taken in a wind trap placed in a warm, lowland pineapple field, but that the *Merothrips morgani* colonies thus far found in Hawaii have been taken in cool, high, mountain localities.

**Merothrips hawaiiensis** Moulton (fig. 216, e).

*Merothrips hawaiiensis* Moulton, 1937:411.

Molokai (type locality).

Immigrant, but as yet known only from the Hawaiian Islands; possibly the same as the following species.

Hostplant: unknown (the type series was taken in a wind trap).

**Merothrips morgani** Hood.

*Merothrips morgani* Hood, 1912:132, pl. 5, figs. 1-3.

Hawaii.

Immigrant. A North American species described from Illinois and Kentucky. First reported from Hawaii by Bianchi (1946:513) from specimens collected in Hawaii National Park by C. J. Davis.

Hostplants: *Heimerliodendron brunonianum*, *Perottetia sandwicensis*, *Pittosporum confertiflorum*, *Santalum paniculatum*, *Urera sandwicensis*.

### Genus **SELENOTHRIPS** (Karny)

*Heliothrips*, subgenus *Selenothrips* Karny, 1911.

**Selenothrips rubrocinctus** (Giard) (fig. 220, d).

*Physopus rubrocinctus* Giard, 1901:264.

*Heliothrips rubrocincta* (Giard) Franklin, 1908:719-723, pl. 64, figs. 10, 14; pl. 65, figs. 17, 20, 21, with detailed redescription.

Bagnall, 1910:699.

The red-banded thrips.

Kauai, Oahu, Molokai, Maui, Hawaii.

Immigrant. A widespread species. First recorded from the Hawaiian Islands by Bagnall (1910:699).

Hostplants: azalea, croton, *Eugenia cumini* (Java plum), guava, *Litchi*, mango, *Passiflora* (passion fruit), *Schinus terebinthifolius* (Christmas berry). A pest in the West Indies.

This species may at times cause considerable damage by causing cracking or silvering of leaves and fruits. Mango fruits may become excessively spotted with the dried excrement of this species, which is clear when dropped but dries to dark-brown blotches. The clear globules, when deposited, may measure 0.5 mm. across, but may dry to over a millimeter in extent, and many hundreds may be present on a single fruit. Moreover, the fruits are sometimes severely damaged by extensive feeding and oviposition. The skin becomes discolored, cracks, wrinkles and shrivels as though dried and sunburned, and the flesh may become flabby beneath the wrinkled skin areas.

The larvae are conspicuously colored. They are basically yellowish with the abdomen bright red across the two basal segments, with most of the other segments tinged with orange. The penultimate abdominal segment is apically tinged with black, and the caudal segment is conspicuously dark brown or black and is armed with six very long, conspicuous, radiating, dark setae. The adults are dark brown with dusky wings, pale feet and bicolored antennae. In life, these insects usually carry the tip of the abdomen curved up over the thorax and are very striking when seen walking about on the host, especially when they have a large globule of excrement held in the "basket" formed by the large, radiating, caudal setae of the brightly colored larvae. They pupate on the host.

Genus **SCOLOTHRIPS** Hinds, 1902:157

This genus contains three species, the best known of which is the following:

**Scolothrips sexmaculatus** (Pergande) (fig. 222, a).

*Thrips 6-maculata* Pergande, 1892:539.

*Thrips pallida* Beach, 1896:226.

*Scolothrips sexmaculatus* (Pergande) Hinds, 1902:157, pl. 4, figs. 42, 45, re-description. Genotype.

Bailey, 1939:43-47, fig. 1, bionomics.

Kauai, Oahu, Hawaii.

Immigrant. Cosmopolitan. First recorded from Hawaii by Bagnall (1910:700) from specimens collected by Fullaway in Honolulu.

Hosts: a predaceous species; feeds on the eggs, young and adults of "red spiders" and other mites. Found on *Psidium*, beans, *Thunbergia grandiflora*, *Xanthium canadense* and on a large number of other plants in Hawaii when they are mite-infested.

This species varies in color from whitish to pale yellow to orange-yellow and has three dark maculae on each fore wing. The mature larvae and pupae are similarly colored. The entire life cycle is passed on the hostplant. The following notes were obtained from Bailey (1939:43-47). Bisexual reproduction appears to be usual. The females lay only about four to six eggs which hatch after six to ten days; the larval stage lasts five days or longer, depending upon food and temperature; the prepupal stage lasts a single day, and the pupal stage about five days; the adults live from two to three weeks.

A most confusing situation exists concerning the original description of this species. Many authors cite the original description as *Trans. St. Louis Acad. Science*, 5:542, 1894. The 1894 volume is 7, not 5, and no paper by Pergande nor a *Thrips 6-maculata* is described in that volume. However, the original description appears as a footnote to a paper by Duffey on Carabidae, Coccinellidae and red spiders in the journal cited, volume 5, published in 1892!

Genus **FRANKLINIELLA** Karny, 1910

## KEY TO THE SPECIES OF FRANKLINIELLA LISTED FROM HAWAII

1. Dark-colored species ..... **fusca** (Hinds).  
Pale species ..... 2
2. Setae mostly hyaline ..... **williamsi** Hood.  
Setae brownish ..... **sulphurea** Schmutz.

**Frankliniella fusca** (Hinds).

*Euthrips fuscus* Hinds, 1902:154, pl. 4, figs. 40, 41.

Hawaii.

Immigrant. Described from Massachusetts. First found in the Hawaiian Islands by William Look at Hilo in 1945.

Hostplant: narcissus (bulbs).

**Frankliniella sulphurea** Schmutz.

*Frankliniella sulphurea* Schmutz, Sitz Ber. Akad. Will. Wien 123:1019, 1913

(I have not seen this reference).

Karny, 1926:195, pl. 17, fig. 2; 1928:255, fig. 2,a.

Oahu, Hawaii.

Immigrant. Perhaps an Oriental species; common in India. First discovered by Pemberton and Holdaway at Poamoho, Oahu, in 1942. (See Proc. Hawaiian Ent. Soc. 11[3]:273, 1943, under *F. occidentalis*.)

Hostplants: flowers of bush and lima beans, eggplant, hibiscus, lantana, monkey-pod, okra, orchids, tomato.

**Frankliniella williamsi** Hood.

*Frankliniella williamsi* Hood, 1915:19, pl. 2, figs. 4, 5.

*Frankliniella flavens* Moulton, 1928:108 (described from Honolulu).

Kauai, Oahu.

Immigrant. Described from North America (type locality: Washington, D. C.). F. A. Bianchi tells me that it has been intercepted at Honolulu on green corn from California. First recorded from the Hawaiian Islands by Moulton, 1928:108.

Hostplants: corn, *Panicum purpurascens*, *Sorghum vulgare*.

This species, essentially a grass thrips having a narrow host range, is always found in large numbers on corn, a preferred host, wherever it grows.... This thrips breeds freely in the folds of rolled heart leaves of young plants as well as in the interspace, usually at the basal portion of the ear, between the overlapping husks of the young or mature ears.... It appears that moist surroundings, such as wet areas near the lower forests and well-irrigated or damp areas of the open lowlands, are the preferred habitat and that increase in populations occurs in the winter months. (Sakimura, in Sakimura and Krauss, 1945:321-322.)

Genus **ORGANOTHRIPS** Hood, 1940:423

**Organothrips bianchii** Hood (fig. 221, a-e).

*Organothrips bianchii* Hood, 1940:423, pl. 24. Genotype.

The taro thrips.

Kauai, Oahu (type locality: Kailua), Molokai, Hawaii.

Immigrant, but not yet recorded elsewhere. Probably a western Pacific species.

Hostplant: taro (*Colocasia*) (irrigated types).

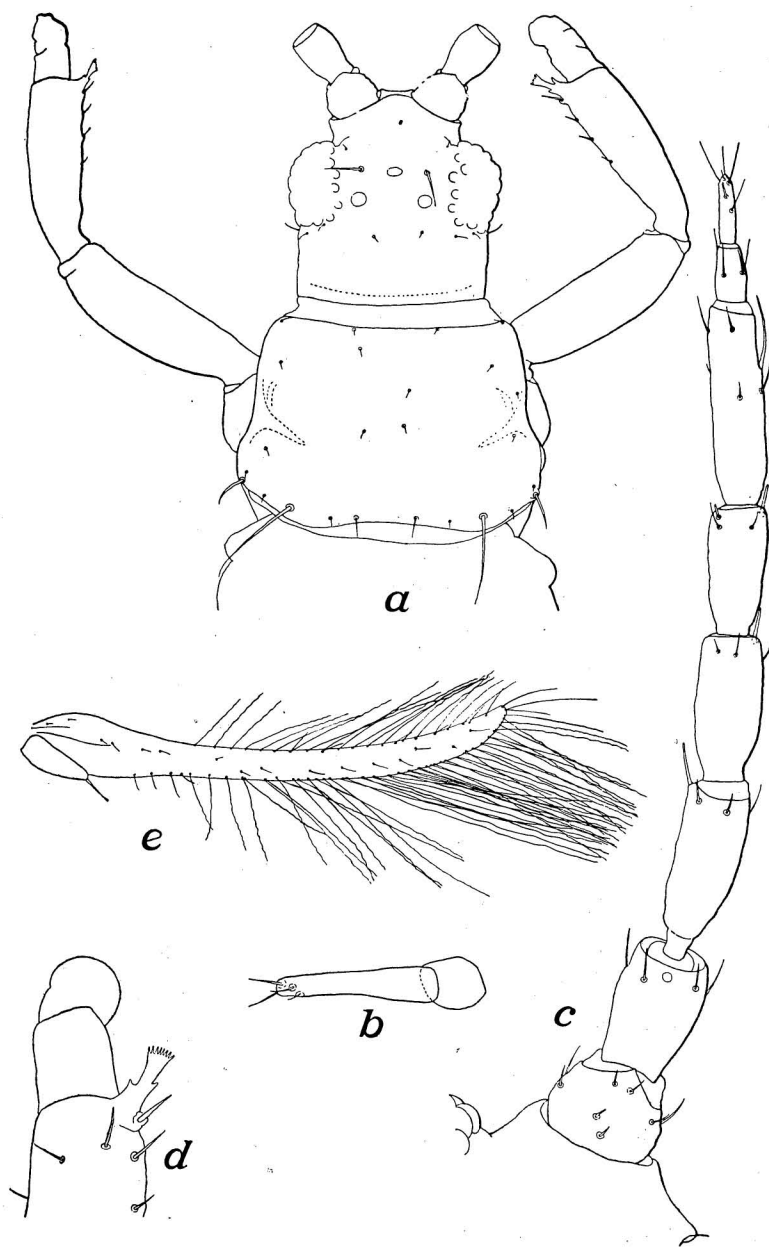


Figure 221—*Organothrips bianchii* Hood. a, head and prothorax, holotype female (all antennal setae, and most of those on legs omitted); b, left maxillary palpus, paratype female; c, left antenna, paratype female; d, left fore tarsus and tip of tibia, paratype female (tarsal setae omitted); e, right fore wing, paratype female. (After Hood, 1940.)

Genus **LEUCOTHIRIPS** Reuter, 1904

*Microthrips* Morgan, 1913:19.

**Leucothrips piercei** (Morgan) (fig. 222, b).

*Microthrips piercei* Morgan, 1913:19, figs. 27–30. Genotype of *Microthrips*.

Kauai, Oahu.

Immigrant. Described from southern United States. First found in the Hawaiian Islands by Sakimura at Moanalua, Oahu, in 1931.

Hostplants: beet, bean, carrot, eggplant, lettuce, mustard, parsley, *Hibiscus*, common on leaves of cocklebur (*Xanthium saccharatum*), radish.

Genus **DOCIDOTHIRIPS** Priesner, 1933

*Stulothrips* Moulton, 1934:499; synonymy by Bianchi, 1945:283.

**Docidothrips trespinus** (Moulton) (figs. 216, d; 219).

*Stulothrips trespinus* Moulton, 1934:500. Genotype.

*Docidothrips trespinus* (Moulton) Bianchi, 1945:283.

Kauai, Oahu (type locality: Hauula), Hawaii.

Immigrant, but not yet known elsewhere.

Hostplants: *Cordyline terminalis*, *Nothopanax*, *Pandanus* (common on male flowers), sugarcane. The only true hostplant in this list, insofar as is now known, is *Pandanus*.

This species is close to *Docidothrips pandani* Kurosawa (1940:46, fig. 1) from the Palau Islands, and it may be the same species, according to Bianchi.

Genus **BREGMATOTHIRIPS** Hood, 1912:66

**Bregmatothrips venustus** Hood (fig. 222, c).

*Bregmatothrips venustus* Hood, 1912:67, figs. 2, a, b; pl. 4, fig. 1. Genotype.

Oahu.

Immigrant. Widespread in North America; described from Texas. First found in the Hawaiian Islands at Waipahu, Oahu, in 1939 by Bianchi (1941:38).

Hostplants: a grass-feeding species; *Echinochloa crus-galli*, Bermuda grass.

Genus **TAENIOTHIRIPS** Amyot and Serville, 1843

## KEY TO THE SPECIES FOUND IN HAWAII

1. Body predominantly pale; wings uniformly dark..... **xanthius** (Williams).  
     ..... Body pale; wings pale ..... **cyperaceae** Bianchi.  
     Body predominantly dark brown; wings either pale or dark... 2

- 2(1). Fore wing with about six distal spines on fore vein.....**simplex** (Morison).  
 Fore wing with about three distal spines on fore vein..... 3
- 3(2). Wings pale .....**alliorum** Priesner.  
 Wings predominantly dark ..... 4
- 4(3). Interocellar spines within ocellar triangle, on a line between  
 anterior margins of posterior ocelli.....**gracilis** Moulton.  
 Interocellar spines on or outside of ocellar triangle, anterior  
 to a line drawn between fore edges of posterior ocelli..... 5
- 5(4). Antennal segments three to five entirely pale; interocellar  
 spines long, on ocellar triangle; anterior ocellus distant  
 from posterior ocelli, all ocelli widely separated.....  
 .....**frici** (Uzel).  
 Antennal segment three pale, four and five dark distad;  
 interocellar spines short, outside triangle; ocelli closely  
 grouped, anterior ocellus very close to posterior ocelli  
 .....**hawaiiensis** (Morgan).

**Taeniothrips alliorum** Priesner.

*Taeniothrips alliorum* Priesner, 1935:128.

*Taeniothrips carteri* Moulton, 1936:183 (type locality: Kilauea, Kauai); syn-  
 onymy by Moulton, 1937:410.

Kauai, Oahu, Molokai, Maui, Lanai, Hawaii.

Immigrant. Widespread; described from Formosa. First recorded from the  
 Hawaiian Islands (as *carteri*) by Moulton (1936:183) from specimens collected  
 on Kauai by Carter.

Hostplants: onion (common), *Emilia sonchifolia*.

**Taeniothrips cyperaceae** Bianchi (fig. 223, D, E).

*Taeniothrips cyperaceae* Bianchi, 1945:283, pl. 17, figs. D, E.

Oahu (type locality: Honolulu), Hawaii.

Immigrant. First found in the Hawaiian Islands in 1940, but not known else-  
 where.

Hostplants: *Cyperus rotundus* (nutgrass), *Solanum nigrum*, *Vinca major*.

Only females have been found. It resembles *Taeniothrips leptospteron* Moulton  
 from New Guinea.

**Taeniothrips frici** (Uzel).

*Physopus frici* Uzel, 1895:126.

Priesner, 1928:288, pl. 4, fig. 61.



Maui, Hawaii.

Immigrant. Widespread. First recorded from Hawaii by Moulton (1937:410) from specimens collected at Olinda, Maui, in 1933 by Linford.

Hostplants: *Acacia koa*, dandelion (*Taraxacum officinale*), *Hypochaeris radicata*, *Styphelia tameiameia*; a flower feeder.

**Taeniothrips gracilis** Moulton.

*Taeniothrips gracilis* Moulton, 1928: 289, pl. 5, fig. 1.

Oahu, Molokai, Hawaii.

Immigrant. Described from Japan and Formosa. First recorded from the Hawaiian Islands by Moulton (1937:410) from specimens collected in 1930 by Sakimura.

Hostplants: *Hymenocallis declinata*; usually a flower feeder, but Bianchi has found it feeding on stems and leaves of *Crinum* and discoloring the plant.

**Taeniothrips hawaiiensis** (Morgan).

*Euthrips hawaiiensis* Morgan, 1913:3, figs. 5-8.

*Thrips albipes* Bagnall, 1914:25; synonymy by Steinweden, 1933:286.

*Thrips hawaiiensis* forma *imitator* Priesner, 1934:267.

Moulton, 1928:110, describes the male. Steinweden (1933:286) suggests that *Physothrips pallipes* Bagnall (1916:397) may also be a synonym. Bianchi has told me that he believes that *Thrips aleuritis* Moulton (1933:29, fig. 1) from Tahiti and *Thrips leucaenae* Moulton (1942:9) from Guam may be synonyms.

The Hawaiian thrips.

Kauai, Oahu (type locality: Honolulu), Molokai, Maui, Hawaii, Midway.

Immigrant. A widespread Oriental species.

Hostplants: This species is a widespread flower feeder which lives in large colonies, and it has been recorded from many families of plants, but mostly from Leguminosae and Convolvulaceae from seashore to mountain tops. It is said to be a minor pest of garden beans, and has been reported to damage orchids. *Acacia confusa*, *Acacia farnesiana*, *Acacia koa*, *Aleurites moluccana*, alfalfa, asparagus, *Astelia menziesiana*, aster, *Argemone alba* var. *glauca* (prickly poppy), avocado, *Batis maritima*, bean, bell pepper, *Buddleia japonica*, bush bean, *Calotropis gigantea* (crown flower), canna, *Cassia leschenaultiana* (misidentified as *mimosoides*), *Cattleya*, *Commelina diffusa* (nudiflora), *Coronopus didymus* (*Senebiera didyma*), cotton, *Crinum*, *Crotalaria juncea*, *Crotalaria mucronata* (saltiana), *Datura stramonium*, *Delonix regia*, *Dendrobium*, *Dioclea violacea* ("maunaloa"); *Dombeya spectabilis*, Easter lily, *Gladiolus*, guava, *Hemerocallis flava*, *Hippobroma longiflora* (Star of Bethlehem), Hubbard squash, *Hydrangea*, *Hypochaeris radicata*, *Ipomoea cairica* (tuberculata), *Ipomoea cairica* var. *lineariloba*, *Ipomoea congesta* (indica and *insularis* in Hawaiian literature), *Ipomoea pes-caprae*, *Lantana*, *Leucaena glauca*, *Macaranga*, *Melaleuca leucadendron*, *Mirabilis jalapa*, monkeypod, native and cultivated *Hibiscus* (occasionally abundant on flowers), *Operculina aegyptia* (*Ipomoea pentaphylla*), orchids, *Pandanus*, pole bean, *Prosopis*, radish, *Rosa*, *Rubus penetrans*,

*Scaevola frutescens*, soy bean, *Spathodea campanulata*, squash, *Styphelia*, *Telosma cordata*, *Tithonia diversifolia* (*rotundiflora*), *Tricholaena repens* (*rosea*), *Tritonia crocosmaeflora* (*potsii*), *Vanda*, *Verbesina encelioides*, *Vitex trifolia* var. *simplicifolia* ("polinalina"), *Waltheria americana*, *Wikstroemia*, *Yucca*.

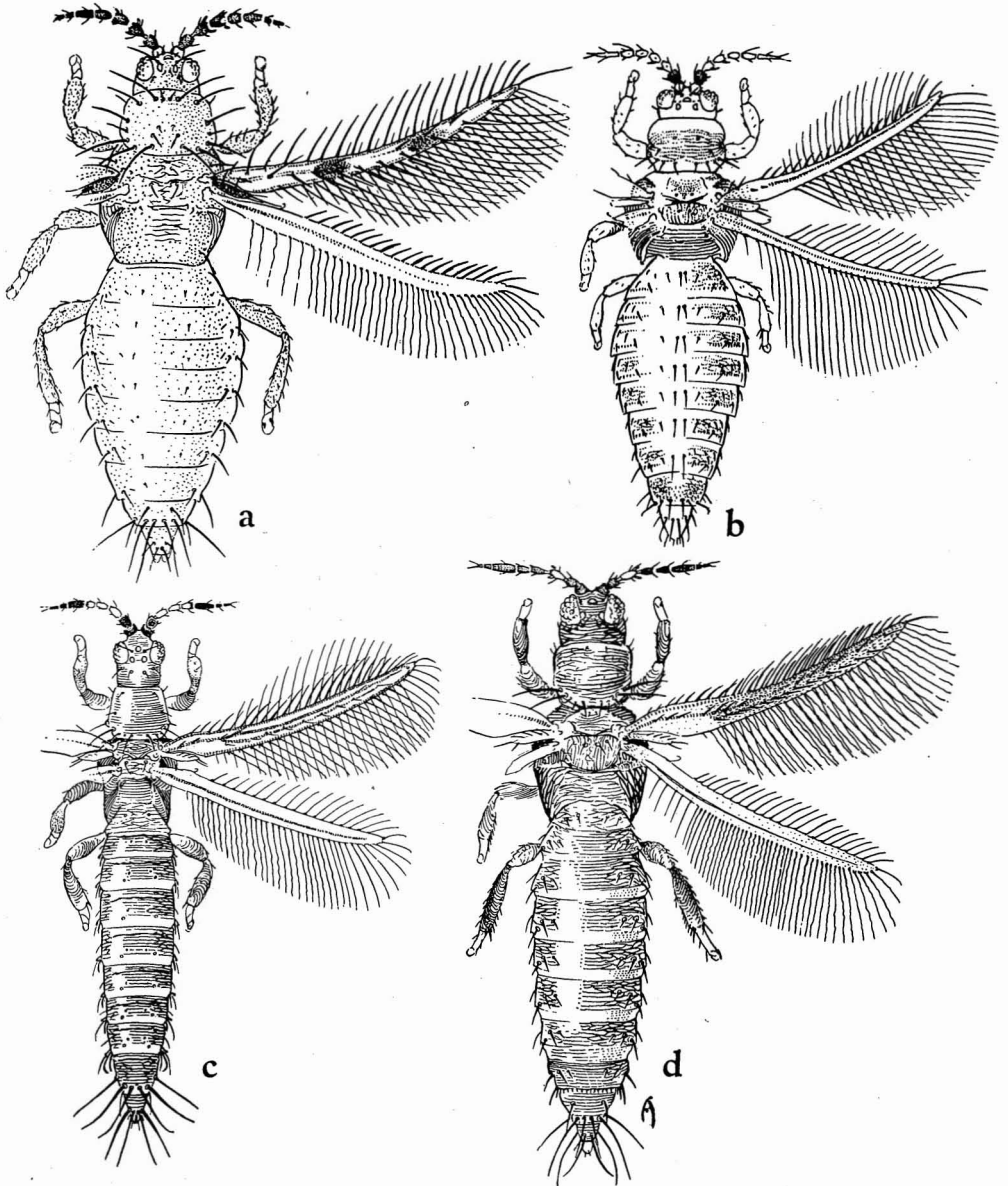


Figure 222—*a*, *Scolothrips sexmaculatus* (Pergande); *b*, *Leucothrips piercei* (Morgan); *c*, *Bregmatothrips venustus* Hood; *d*, *Taeniothrips simplex* (Morison). (Abernathy drawings; not to same scale.)

Control: tartar emetic sprays have been used with success in controlling this thrips on orchids.

This is a confusing species. One of the principal characters used to separate *Taeniothrips* from *Thrips* is whether the antennae are seven-segmented (*Thrips*) or eight-segmented (*Taeniothrips*). Yet, one may find both seven- and eight-segmented individuals of this species in the same colony. Moreover, some specimens have one antenna seven-segmented, the other eight-segmented. Specimens with only six antennal segments are seen occasionally, as are other irregularities. Sakimura (Sakimura and Krauss, 1944:117) found 91 out of 107 individuals examined to have eight-segmented antennae (the form *imitator* of Priesner). No colonies have been seen in which all the individuals had the same number of antennal segments. I have, therefore, placed this species in the key to *Thrips* as well as in *Taeniothrips*. It is frequently taken in company with *Thrips tabaci*. Takahashi (1936) reported that this species is the most dominant and polyphagous thrips in Formosa.

***Taeniothrips simplex* (Morison) (fig. 222, d).**

*Physopus simplex* Morison, 1930:12.

*Taeniothrips gladioli* Moulton and Steinweden, 1931:20, fig. 1. Synonymy by Moulton, 1936:184.

The gladiolus thrips.

Kauai, Oahu, Maui, Hawaii.

Immigrant. Widespread. First discovered in Hawaii by Chock in 1932 in Honolulu.

Hostplants: a pest of *Gladiolus*, *Tritonia crocosmaeflora*.

When this pest first appeared in Hawaii, it spread rapidly, caused great damage, forced some gladiolus growers out of business and caused some amateur breeders to give up gladiolus growing. However, the severity of attack has dwindled greatly, and we do not have many complaints of heavy damage done by it now.

The attacks of this species cause bleaching or silvering of the leaves, the flowers fail to develop properly and become streaked and bleached, normal growth is inhibited, new corms are not developed and heavy infestation of corms causes them to shrivel and fail to germinate. The thrips continue feeding on stored corms.

McKenzie (1935:4) found that in the summer in California the length of the life cycle was from 14 to 19 days. The females can reproduce parthenogenetically, but without mating give rise only to males. A single female may lay between 100 and 200 eggs over a period of one to two and one-half months. The white eggs take five to six days to hatch; the first-stage larvae are translucent white with red eyes and develop in two to three days; the second-stage larvae are pale yellow and last two to four days; the prepupa is orange and lasts two to three days; the pupa, which lasts three days, is at first orange, but soon turns to yellow with large red eyes and its wing pads extend to abdominal segments seven or eight. "The adult ...

is dark-brown to black with the head and thorax usually darker than the abdomen. The wings have a light-colored area at the base where they join with the thorax and when folded give the appearance of a band across the insect." (McKenzie, 1935:4.)

Parasite: *Thripoctenus russelli* Crawford (Hymenoptera: Eulophidae).

Control: McKenzie (1935) recommends a spray consisting of manganese arsenate,  $\frac{1}{4}$  pound; brown sugar,  $4\frac{1}{8}$  pounds; and water,  $6\frac{1}{4}$  gallons (or, for large quantities, 4 pounds, 66 pounds, and 100 gallons of water, respectively). "In order to insure clean flowers and to prevent rapid increase in population of the thrips, it is necessary to begin spraying when the plants are about 2 inches high." (McKenzie.) Spraying should be done once a week. More recent studies have shown that a spray made from two pounds tartar emetic and four pounds brown sugar in 100 gallons of water is an effective spray, and it has been widely adopted. Another good spray is one quart of 40 percent nicotine sulphate and three gallons of corn syrup to 100 gallons of water. For control on the stored corms, naphthalene flakes are effective and easy to use. Use an ounce to each 100 corms placed in a tightly closed paper bag for at least three weeks. Corrosive sublimate mixed one ounce to seven gallons of water kills all stages on unpeeled corms dipped for 17 hours.

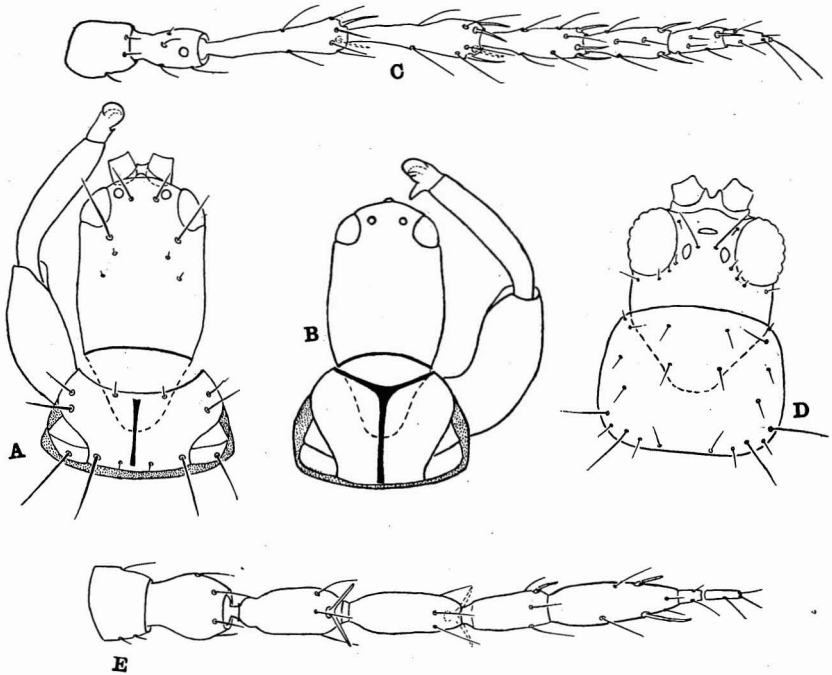


Figure 223—Details of some thrips: A, *Rhaebothrips major* Bagnall, macropterous female; B, the same, macropterous male, all setae omitted; C, the same, left antenna of female, dorsal view; D, *Taeniothrips cyperaceae* Bianchi, macropterous female; E, left antennae of same, dorsal view with some minor setae omitted. (After Bianchi, 1945.)

**Taeniothrips xanthius** (Williams).

*Physothrips xanthius* C. B. Williams, 1917:59, fig. 1.

Oahu.

Immigrant. Described from Trinidad, British West Indies. First found in Hawaii by Swezey in 1935 at Honolulu.

Hostplants: orchid, *Cypripedium*, *Cattleya*, *Asystasia gangetica*.

Control: nicotine sulphate diluted 1:400 to 600 has been recommended for use on orchids.

"The larvae and pupae are found with the adults on the upper surfaces of the leaves [of *Cattleya* orchids], particularly near the mid rib and toward the base of the leaf. They cause injury by piercing the surface, resulting in brownish spots or patches on the leaves. In severe cases the plant may be entirely killed." (C. B. Williams, 1917:61.)

Sakimura (Proc. Hawaiian Ent. Soc. 12 [1]:26, 1944) recommends keeping orchid houses free from the alternate host *Asystasia gangetica* as essential to the control of this pest. It is our worst thrips pest of orchids.

Genus **PlesiOTHrips** Hood, 1915:129**PlesiOTHrips panicus** (Moulton).

*Thrips panicus* Moulton, 1929:61.

*PlesiOTHrips panicus* (Moulton) Hood, 1936:258.

Kauai, Oahu, Molokai (type locality).

Immigrant. Widespread. First recorded from the Hawaiian Islands by Moulton, 1929:61. The type series consisted of specimens from sugarcane from Hawaii and *Panicum maximum* from Cuba.

Hostplants: *Cenchrus echinatus*, *Digitaria sanguinalis* (*Syntherisma sanguinalis*), *Echinochloa crus-galli*, *Echinochloa crus-pavonis*, *Eleusine indica*, *Emilia sonchifolia*, *Pandanus* (male flowers), *Paspalum conjugatum*, *Paspalum dilatatum*, pineapple, rice, *Setaria geniculata*, sugarcane, *Trichachne insularis* (*Valota insularis*).

Hood (1936:258) says that this species is "closely allied to, if not identical with, *P. perplexus* (Beach)," the genotype, which is figured by Hood, 1915:129.

Genus **THRIPS** Linnaeus, 1758:457

This is a large, complex group which is largely in a taxonomic muddle.

## KEY TO THE SPECIES OF THRIPS FOUND IN HAWAII

(Excepting *Thrips multispinus* Bagnall, which I have not seen.)

1. Caudal margins of abdominal tergites one to eight serrate (difficult to see on some specimens); on Compositae (subgenus *Microcephalothrips*) . . . **abdominalis** (Crawford).  
At most only hind margins of seventh and eighth abdominal tergites serrate . . . . . 2

- 2(1). Fore wings yellow, but with a brown band at middle and at apex (part of subgenus *Isoneurothrips*) ..... **fasciatus** (Moulton).  
Fore wings not banded ..... 3
- 3(2). Ocellar crescents gray or olive colored (Note: in cleared specimens it will not be possible to tell the color; proceed to part 4) ..... **tabaci** Lindeman.  
Ocellar crescents orange or reddish ..... 4
- 4(3). Fore wing with anterior vein closely, unusually evenly set with numerous stout spines beyond middle, the spines often evenly placed from near base to apex (subgenus *Isoneurothrips*) ..... 5  
Fore wing with anterior vein with only a few irregularly placed stout spines beyond middle (subgenus *Thrips*) ..... 10
- 5(4). Predominantly dark-brown species ..... 6  
Pale yellowish or brownish-yellow species ..... 7
- 6(5). Antennae comparatively long and slender, length about 300 microns ..... **antennatus** (Moulton).  
Antennae comparatively short and stout, length about 225 microns ..... **fullawayi** (Moulton).
- 7(5). Antennae with four basal segments pale, the others brownish ..... **dubautiae** (Moulton).  
Antennae with only the basal first or first and second segments pale ..... 8
- 8(7). Antennae with first two segments pale. .... **carteri** (Moulton).  
Antennae with only first segment pale ..... 9
- 9(8). Fore wing with about 38 costal spines; caudal abdominal segment dark brown in female. .... **australis** Bagnall.  
Fore wing with about 28 costal spines; caudal abdominal segment concolorous with remainder of abdomen in female ..... **williamsi** (Moulton).
- 10(4). Predominantly yellowish species ..... 11  
Predominantly brown species ..... 12
- 11(10). Body spines long, stout, dark brown; antennal segments three to seven dark brown, two pale brown; interocellar spines strongly developed and conspicuous. .... **nigropilosus** Uzel.  
Body spines short, pale brown; antennal segments three to seven pale brown, two dark brown; interocellar spines minute and inconspicuous. .... **tabaci** Lindeman.
- 12(10). Legs dark brown. .... **trehernei** Priesner.  
Legs pale ..... 13
- 13(12). Antennal segments three and four pale; anteocellar spines strongly developed, longer than interocellar spines. .... **saccharoni** Moulton.  
Antennal segment three only pale; anteocellar spines inconspicuous, much shorter than interocellar spines [Note: if your specimen runs to here, it may be *Taeniothrips hawaiiensis* (there is no *Thrips hawaiiensis*) which is a variable and confusing species. See discussion under *Taeniothrips*] ..... **Taeniothrips hawaiiensis** (Morgan).

Subgenus **Microcephalothrips** (Bagnall, 1926:113, as a genus) Priesner, 1928:442

**Thrips (Microcephalothrips) abdominalis** (Crawford) (fig. 226, a).

*Thrips abdominalis* Crawford, 1910:157, fig. 65.

*Microcephalothrips abdominalis* (Crawford) Bagnall, 1926:114. Genotype of *Microcephalothrips*.

See Bailey, 1937:121, for discussion, illustrations and detailed synonymy.

The composite thrips.

Kauai, Oahu, Maui, Hawaii.

Immigrant. Nearly cosmopolitan. First recorded from the Hawaiian Islands by Moulton (1928:110) from specimens collected by Swezey at Honolulu in 1926 and 1927.

Hostplants: aster, *Bidens pilosa*, *Chrysanthemum*, *Emilia coccinea*, *Emilia sonchifolia*, *Erigeron*, *Gaillardia pulchella*, *Ipomoea congesta (indica)*, *Ipomoea pes-caprae*, *Lantana*, *Malva*, *Tithonia diversifolia*, *Verbesina encelioides*.

This is a variable species which may be macropterous or brachypterous. The entire life cycle is passed in the flower heads. Bailey (1937:125) reports that "The eggs are inserted in the more tender portions of the flower parts, stems and buds. The length of the egg stage was not definitely determined but is probably in the neighborhood of five days. During the early fall [in California] the larval stage extends over a period of two weeks. The prepupal stage lasted one to two days and the so-called pupal stage two to three days. The pupae are found unprotected in the flower heads only, in company with all other stages." He noted that the predaceous bug *Orius tristicolor* White fed on this species in California.

#### Subgenus **Thrips** (Linnaeus, 1758)

**Thrips (Thrips) nigropilosus** Uzel.

*Thrips nigropilosus* Uzel, 1895:198, pl. 6, figs. 105-106.

Priesner, 1928:409.

The chrysanthemum thrips.

Kauai, Oahu, Maui, Hawaii.

Immigrant. Cosmopolitan. First recorded from the Hawaiian Islands by Moulton (1937:410) from specimens collected by Sakimura at Kapahulu, Oahu, in 1936.

Hostplants: aster (injury to seedlings), *Arctium lappa* (burdock), carrot, celery, *Chrysanthemum*, *Datura stramonium*, eggplant, *Emilia sonchifolia*, *Hypochaeris radicata*, lettuce (damage done; the most important thrips on this host in Hawaii), *Plantago lanceolata*, potato, spinach.

Control: nicotine sulphate, derris extract sprays and sulphur dusting have been used successfully.

**Thrips (Thrips) saccharoni** Moulton (figs. 225; 226, d).

*Thrips saccharoni* Moulton, 1928:111, pl. 1, fig. 1.

The sugarcane thrips.

Kauai, Oahu (type locality: Honolulu), Molokai, Hawaii.

Immigrant. Tropicopolitan.

Hostplants: corn, *Panicum pupurascens* (*barbinode*), sugarcane.

"It often fairly swarms in and about the central leaf-roll of the sugarcane plant and is quite active, and when exposed may jump and fly away." (F. X. Williams, 1931:94.) When abundant, it may cause mottling of the leaves.

Sakimura (Sakimura and Krauss, 1945:322) reports that perhaps wetland and dryland phases occur which differ in coloration. Sometimes both "forms" are found together on the same plant.

**Thrips (Thrips) tabaci** Lindeman (figs. 224; 226, c).

*Thrips tabaci* Lindeman, 1888:15, 61-75.

For detailed synonymy, see Priesner, 1928:433, and Hinds, 1902:179-184; for description, notes and illustrations, Speyer, 1934; for bionomics in Hawaii, see Sakimura, 1932:884-891.

The onion thrips.

Kauai, Oahu, Molokai, Lanai, Maui, Hawaii, Midway, Kure (Ocean).

Immigrant. Cosmopolitan. First recorded in the Hawaiian Islands by Fullaway in 1915.

Hostplants: *Acacia farnesiana*, *Acacia koa*, *Acanthospermum australe* (*xanthoides*), *Ageratum conyzoides*, alfalfa, *Amaranthus viridis* (*gracilis*), *Amaranthus retroflexus*, *Anthurium*, bell pepper, *Bidens pilosa*, *Bothriospermum tenellum*, *Brassica chinensis*, *Brassica nigra*, broad bean, broccoli, cabbage, *Callistephus chinensis* (Chinese aster), carnation, carrot, *Cassia leschenaultiana* (misidentified as *mimosoides*), *Cassia occidentalis*, *Cassia tora*, cauliflower, celery, *Cenchrus*, *Centella asiatica* (*Hydrocotyle asiatica*), chard, chicory, *Coronopus didymus* (*Senebiera didyma*), *Crotalaria juncea*, *Crotalaria mucronata* (*saltiana*), *Crotalaria spectabilis*, *Cucumis dipsaceus*, *Cuphea carthagenensis* (misidentified as *hyssopifolia*), *Digitaria violascens* (*Syntherisma chinensis*), *Digitaria sanguinalis*, *Datura stramonium*, edible-pod pea (*Pisum sativum*), eggplant, *Eleusine indica*, *Emilia coccinea*, *Emilia sonchifolia* (*sagittata*), endive, *Erechtites hieracifolia*, *Erigeron albidus*, *Erigeron canadensis*, *Euphorbia hirta*, *Franseria strigulosa* (*Ambrosia artemisiaefolia*), *Gnaphalium luteo-album*, *Ipomoea congesta*, *Ipomoea cairica* (*tuberculata*), kohlrabi, *Lantana camara*, lettuce, *Leucaena glauca*, *Lupinus*, *Malva*, *Mimosa pudica*, *Mirabilis jalapa*, nasturtium, New Zealand spinach, *Nicandra physalis*, *Nicotiana*



*glutinosa*, *Nothopanax guilfoylei*, onion (a preferred host), *Oxalis martiana*, papaya, parsley, *Paspalum conjugatum*, *Phaseolus lathyroides*, *Phytolacca acinosa*, pigeon pea, pineapple, *Pluchea indica*, *Portulaca oleracea*, potato, *Prosopis chilensis* (*juliflora*), radish, *Richardia scabra* (*Richardsonia scabra*), rose, *Solanum nodiflorum*, *Sonchus oleraceus*, soy bean, *Stachys arvensis*, *Stachytarpheta cayennensis* (*dichotoma*), stocks, *Tithonia rotundifolia*, tobacco, tomato, *Tricholaena repens*, *Verbena litoralis* (misidentified as *V. bonariensis*), *Vernonia cinerea*, *Vigna sinensis*, *Waltheria americana*, white radish, *Yucca*.

Parasites: *Thripoctenus brui* Vuillet, *Thripoctenus russelli* Crawford (Hymenoptera: Eulophidae).

Predators: *Aeolothrips fasciatus* (Linnaeus), *Scolothrips sexmaculatus* (Pergeande) (predaceous thrips).

This species causes concern to the growers of pineapples and many truck crops in the islands, and it is a transmitter of yellow-spot virus. The wide host range of the species makes it difficult to control. It is the most important of all the thrips pests.

Reproduction in this species in Hawaii is mostly by parthenogenesis. Only five out of 5,000 specimens examined by Sakimura (1932:887) were found to be males. In Hawaii the average length of life cycle and stages has been found by Sakimura (1932:890) to be as follows: egg, 4.5 days; first instar, 4.6; second instar, 4.6; prepupal, 1.5; pupal, 3.3; life cycle, 18.5; preoviposition period, 6; duration of oviposition, 22.5; postoviposition period, 4; average number of eggs deposited by unmated females, 37.4. Large populations develop quickly under Hawaiian conditions.

The feeding scars on *Emilia sonchifolia* (*sagittata*) are described by Sakimura (1932:886) as follows: "the silvery whitish sunken area is the direct result of their attack. Young terminal leaves frequently show malformations when heavily attacked, with crinkly surfaces, sunken and raised thin areas, marginal erosion, margin curling inwardly and a chlorotic yellowish appearance with grayish color along all the large veins. These injuries are produced by both viruliferous and non-viruliferous insects. The malformed leaves appear in bunchy form on terminals."

Because of the importance of this pest in the transmission of pineapple yellow-spot virus, the Pineapple Research Institute of Honolulu imported the internal parasite *Thripoctenus brui* Vuillet from Japan in 1932-1934 to aid in its control (see Sakimura, 1937:799). Considerable research concerning virus transmission by this species has been conducted by members of the Pineapple Research Institute (see bibliography). The virus attacks a number of wild hostplants, among which is *Emilia sonchifolia* (*sagittata*), a common, widespread weed and a favorite host of the thrips.

Sakimura (1940:281) presented new data and reviewed the old evidence to show that pineapple yellow-spot is the same as tomato spotted-wilt, which attracted notice in Hawaii in 1937 and has since caused considerable trouble in the islands. Pineapple yellow-spot was first noticed in Hawaii in 1926. This disease is carried

by *Thrips tabaci* to a number of other plants, including *Emilia* species, spinach, broad bean, celery, potato, eggplant, bell pepper, tobacco, *Nicotiana glutinosa*, *Datura stramonium*, *Petunia*, chicory, endive and lettuce; but beet, Swiss chard, cabbage, cauliflower, New Zealand spinach, *Commelina diffusa*, *Commelina benghalensis* and summer *Chrysanthemum* are not susceptible, according to Sakimura (1940: 297). Tomato plantings sometimes suffer extensive damage as a result of the disease.

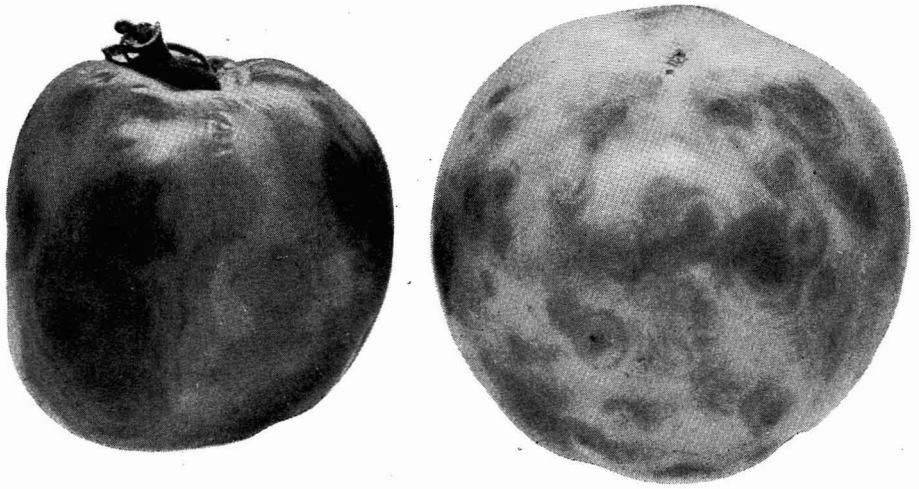


Figure 224—Tomato fruits showing symptoms of yellow spotted-wilt of tomatoes which is transmitted by *Thrips tabaci* Lindeman. (Photograph by K. Sakimura, Pineapple Research Institute.)

Linford (1932:301–324) noted that although yellow-spot is one of the major diseases of pineapple in Hawaii and may kill the plants (but see note below by Sakimura), “The pineapple plant, even as a young seedling, appears relatively unfavorable for the growth and reproduction of *Thrips tabaci*...” (p. 312). He found the incubation period for the virus in the *Thrips* to be about 10 days, and in *Emilia sonchifolia* (*sagittata*) it is about 15 days (mean) and in pineapple, 12 days (mean). Adult thrips raised from larvae on non-infected plants cannot transmit the disease, even if they feed, as adults, on infected plants, but adults reared from larvae raised on infected plants can transmit the disease to a healthy plant.

Carter (1939:275) said,

It is evident...that a considerable reservoir of virus may exist in the pineapple fields with little or no transfer to pineapple plants taking place. This is readily explainable on the difference in suitability of the two plants as thrips hosts. A few scattered wind-blown thrips would be sufficient to infest and infect the relatively small populations of *Emilia* present. Infestation of pineapple plants, however, does not occur except rarely and even then only for a short period during blossoming, the thrips' sojourn on pineapple being transient. This transient stage is sufficient to infest the pineapple if the insect is viruliferous and the plant susceptible. There is no evidence to indicate movement of thrips from pineapple to pineapple,

nor is movement from undisturbed *Emilia* growing among pineapple to nearby pineapple plants likely. There is, furthermore, no correlation between *Thrips tabaci* populations on *Emilia* in the sampled areas and disease in nearby pineapple fields, probably for the same reason, that undisturbed *Emilia* is a favoured host from which movement does not normally occur.

Sakimura (1947:85) says, however, that "with the exception of some minor localized outbreaks here and there, this disease has rarely proved to be serious" to pineapples.

Occasionally, the young leaves of papaya are deformed by attacks of this species. Onions are severely attacked in dry areas or at times of drought. It is a minor pest of garden beans and occasionally causes damage to cabbage.

Control: Carter (1932:1031) reported that tobacco dust was the most effective insecticide used in the control of yellow-spot on pineapples. Other workers have used nicotine sulphate successfully for control on onions and asparagus which have been damaged in the islands. Overhead irrigation or spraying with water is a simple and effective control practice where possible. The use of tartar emetic-sugar-water (2-4-100 parts) spray has been found to be successful for control on onions in some places on the mainland. The spray is applied five or six times at about weekly intervals when the onions reach a height of four to six inches.

Sakimura has told me that he has noted that the rainy-season, winter form of this species is darker in color in Hawaii than the summer form.

**Thrips (Thrips) trehernei** Priesner.

*Thrips trehernei* Priesner, 1928:356, footnote.

Oahu.

Immigrant. Widespread. This species was recorded from Hawaii for the first time by Moulton (1936:184) from a single example taken from a pineapple at Honolulu in 1930 by Ito.

Hostplant: pineapple (?).

Subgenus **Istoneurothrips** (Bagnall, 1915)

In addition to the following species, other new forms are known to occur here.

**Thrips (Istoneurothrips) antennatus** (Moulton).

*Istoneurothrips antennatus* Moulton, 1928:112.

Endemic (?). Oahu (type locality: Mount Tantalus), Molokai, Maui, Hawaii.

Hostplants: *Astelia menziesiana*, *Broussaisia*, *Metrosideros collina polymorpha* (sometimes found in abundance in the blossoms), *Vaccinium*.

**Thrips (*Isoneurothrips*) *australis* Bagnall.**

*Thrips (Isoneurothrips) australis* Bagnall, 1915:592.

Kauai, Oahu, Molokai, Lanai, Maui, Hawaii.

Immigrant. Described from Australia and known from Tasmania. First found in the Hawaiian Islands by F. A. Bianchi in 1938 in the Honouliuli Forest Reserve, Oahu.

Hostplants: *Buddleia japonica*, *Eucalyptus robusta*, guava, *Leucaena glauca*, *Metrosideros*, *Pittosporum undulatum*. A flower species which evidently feeds on nectar.

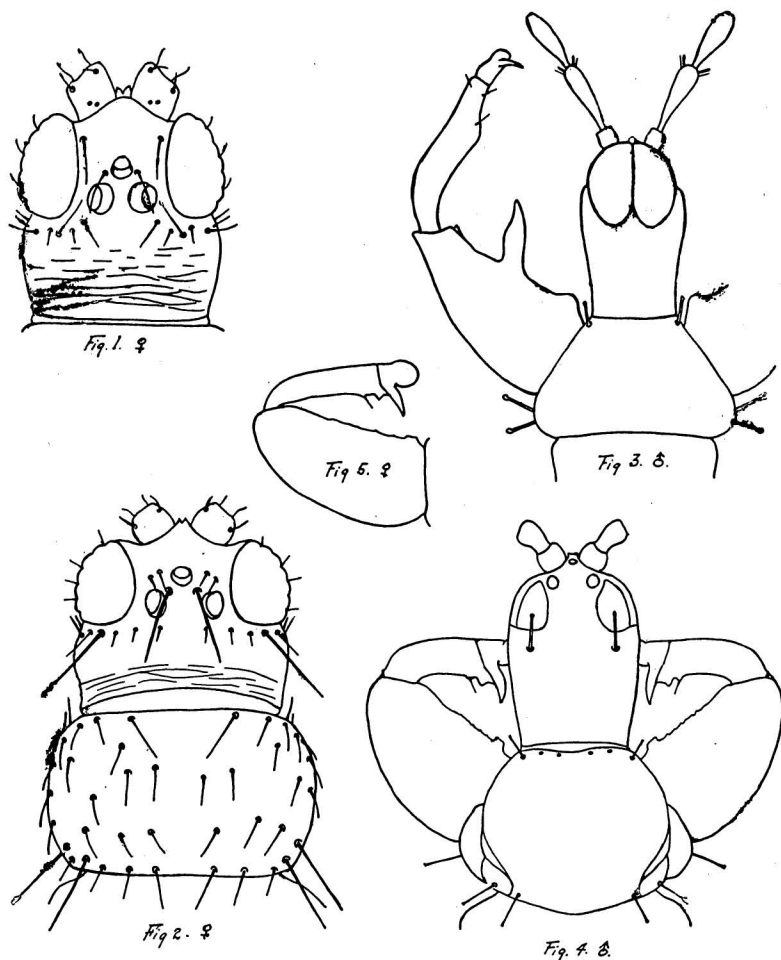


Figure 225—Details of some thrips: 1, *Thrips (Thrips) saccharoni* Moulton; 2, *Thrips (Isoneurothrips) fullawayi* (Moulton); 3, *Macrophthalmothrips hawaiiensis* Moulton; 4, *Podothrips (Kentronothrips) lucaseni* (Krüger), with fore leg of female at 5. (After Moulton, 1928.)

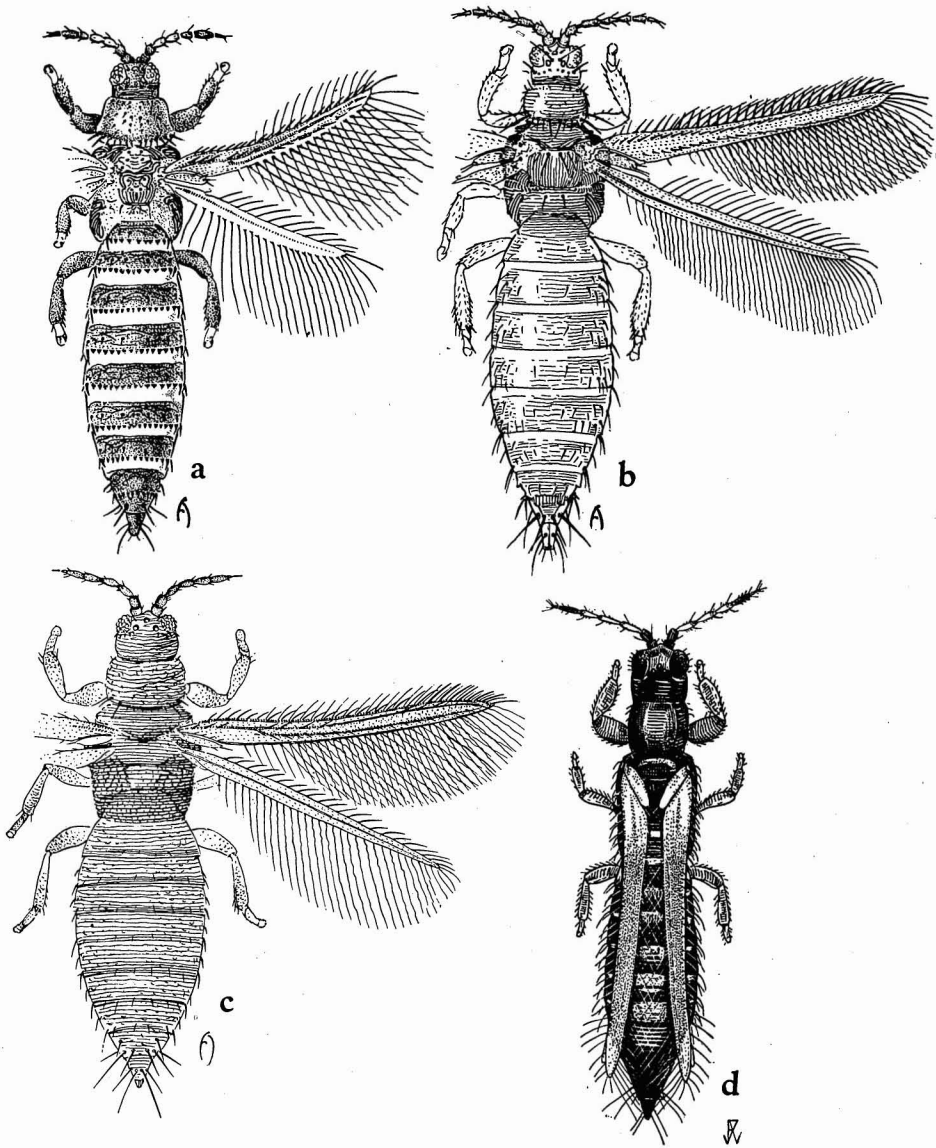


Figure 226—**a**, *Thrips* (*Microcephalothrips*) *abdominalis* (Crawford); **b**, *Thrips* (*Ioneurothrips*) *fullawayi* (Moulton); **c**, *Thrips* (*Thrips*) *tabaci* Lindeman; **d**, *Thrips* (*Thrips*) *saccharoni* Moulton. (Figure **d** by Williams, others by Abernathy; not to same scale.)

**Thrips (*Ioneurothrips*) *carteri* (Moulton).**

*Ioneurothrips carteri* Moulton, 1937:411.

Endemic (?). Oahu (type locality: Kipapa), Hawaii.

Described from a unique specimen taken in a wind trap in a pineapple field. F. A. Bianchi found it associated with rust fungus on *Acacia koa* at Kilauea, Hawaii.

**Thrips (Isoneurothrips) dubautiae** (Moulton).

*Isoneurothrips dubautiae* Moulton, 1928:113.

Endemic (?). Oahu (type locality: Mount Tantalus).

Hostplants: *Dubautia*, *Delonix regia*.

**Thrips (Isoneurothrips) fasciatus** (Moulton).

*Isoneurothrips fasciatus* Moulton, 1937:410.

Endemic (?). Oahu (type locality: Kipapa).

Described from a unique specimen collected in a wind trap in a pineapple field.

**Thrips (Isoneurothrips) fullawayi** (Moulton) (figs. 225; 226, b).

*Isoneurothrips fullawayi* Moulton, 1928:114, pl. 1, fig. 2.

Endemic (?). Kauai, Oahu (type locality: Pauoa Valley).

Hostplants: *Broussonetia papyrifera*, *Broussaisia arguta* (in flower), *Ipomoea congesta*, *Pipturus* and other unrecorded hostplants. F. A. Bianchi found young and adults feeding on leaves of *Pipturus*.

**Thrips (Isoneurothrips) multispinus** (Bagnall).

*Thrips multispinus* Bagnall, 1910:699, pl. 17, figs. 15-20.

Endemic (?). Kauai, Oahu(?), Molokai, Maui(?), Hawaii (type locality not designated by Bagnall).

The male and female types and two cotype females are mounted on slides, and two cotype females are mounted on a card in the British Museum.

I have seen no authentic specimens of *Thrips multispinus* and have been unable to place it in the key. According to Moulton (1928:116), his *fullawayi* is close to *multispinus*. If his conclusions, based upon Bagnall's description only, are correct, then *multispinus* would evidently run to couplet six in the key. In a comparative table given by Moulton (1928:116), he notes that the female of *multispinus* is supposed to have the prothorax distinctly longer than the head, whereas the two are subequal in length in *fullawayi*, that the antennal style is one-fourth the length of segment six in *multispinus* and one-half the length of that segment in *fullawayi* and that *fullawayi* is 0.92 mm. long, whereas *multispinus* is only 0.65 mm. in length. Hood, in a letter to Bianchi, stated that he had examined one of Bagnall's original specimens, and that the example was closely similar to *fullawayi* but the antennae were stouter as in Bagnall's figure. I cannot help but believe that some synonymy is involved here and that one of the species names currently used in Hawaii really applies to Bagnall's *multispinus*.

**Thrips (Isoneurothrips) williamsi** (Moulton).

*Isoneurothrips williamsi* Moulton, 1928:115.

Endemic (?). Kauai, Oahu (type locality: Mount Tantalus), Hawaii.

Described from a unique specimen.

Hostplants: *Acacia koa*, *Metrosideros*, *Myoporum sandwicense*, *Sophora chrysophylla*; a flower species found on various plants in both lowlands and highlands.

**Suborder TUBULIFERA** Haliday, 1836

This suborder contains the largest of the Thysanoptera. In general, the species are of more cryptic habit than those of the Terrebrantia, and many live beneath dead bark, in dead wood, or in trash. Many are known to be predaceous or fungivorous. They usually are more sluggish than the members of the Terrebrantia, and many are restricted in their host preferences. This is the dominant group of thrips in our native forests.

The ovipositor is wanting in the members of this suborder and the females lay their eggs loosely about in cracks or on the surface of their place of abode; they are not inserted in plant tissues as are those of the Terrebrantia. The females may be distinguished by the fact that the ventral basal margin of the tube is entire, and there is a short, heavily sclerotized, longitudinal bar-like structure visible near the posterior edge of the ninth sternite. The males lack this structure, and the basal, ventral margin of the tube is emarginate.

**KEY TO THE SUPERFAMILIES OF TUBULIFERA**

1. Maxillary palpi two-segmented; antennae seven-, or usually eight-segmented; mid coxae more widely separated than other pairs; abdominal segment nine not or rarely longer than eight; caudal abdominal bristles rarely longer than tube..... **Phlaeothripodea.**
2. Maxillary palpi one-segmented; antennae four- to seven-segmented; metacoxae more widely separated than fore or middle pairs; abdominal segment nine longer than eight; caudal abdominal bristles conspicuously longer than tube..... **Urothripodea.**

**Superfamily PHLAEOTHRIPOIDEA** Hood, 1915:58

Haliday's original spelling of the type genus is *Phlaeothrips*, not *Phloeothrips* as was used by Burmeister in his *Handbuch* in 1838 and by many subsequent authors.

**Family PHLAEOTHRIPIDAE** Uzel, 1895

The arrangement of this family is in chaos. I have been unable to use the characters given by any author to separate the various Hawaiian representatives into the described subfamilies and tribes. The classifications followed by Hinds,

Karny (adapted by Watson) and Priesner differ in almost every way. It has been impossible to fit many genera into Watson's translations (1923) of Karny's keys (1921). It is, I believe, the task of a skilled, broadly trained specialist in the Thysanoptera to present an adequate classification and arrangement of the Hawaiian Phlaeothripidae, for such a revision is beyond the scope of this volume and beyond my present ability and experience. I have, therefore, drawn up a tentative key to the genera from Hawaiian material and have not attempted to follow the key characters used by other workers. If this text will enable local workers to place their species, its purpose will be satisfied.

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According to Priesner's work (1928), the genera of Tubulifera found in Hawaii would be arranged as follows:

**Phlaeothripodea**

**Phlaeothripidae**

**Phlaeothripinae**

**Phlaeothripini**

*Phlaeothrips* Haliday.

**Hoplothripini**

*Agnostochthona* Kirkaldy.

*Dermothrips* Bagnall.

*Hoplothrips* Amyot and Serville.

*Liothrips* Uzel.

*Macrophthalmothrips* Karny.

*Nesothrips* Kirkaldy.

*Polyporothrips* Watson.

**Haplothripini**

*Aleurodothrips* Franklin.

*Haplothrips* Amyot and Serville.

*Karnyothrips* Watson.

*Podothrips* Hood.

**Megathripinae**

**Compsothripini**

*Rhaebothrips* Karny.

*Dichaetothrips* Hood.

*Diceratothrips* Bagnall.

**Urothripodea**

**Urothripidae**

*Stephanothrips* Trybom.

*Conocephalothrips* Bianchi.



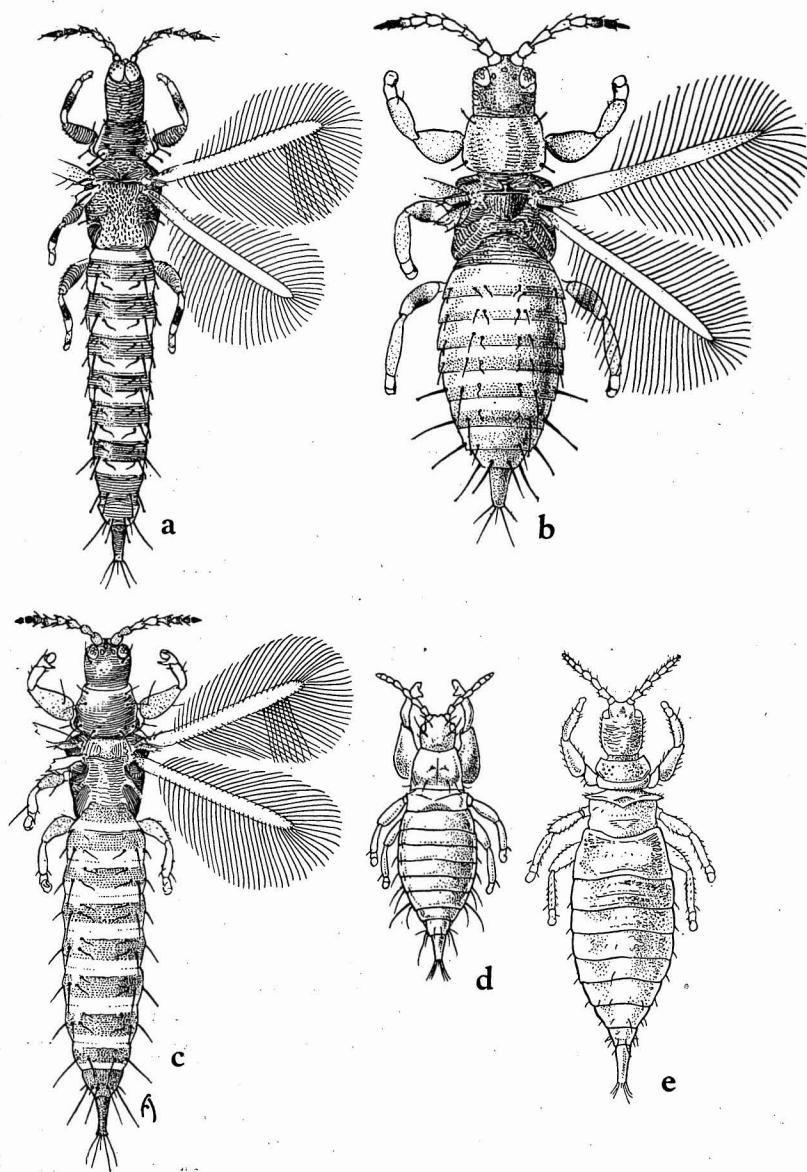


Figure 227—**a**, *Macrophthalthrips hawaiiensis* Moulton; **b**, *Aleurodothrips fasciapennis* (Franklin); **c**, *Hoplothrips flavitibia* Moulton; **d**, *Nesothrips oahuensis* Kirkaldy (redrawn from Bagnall, 1910); **e**, *Dermothrips hawaiiensis* Bagnall (redrawn from Bagnall, 1910). (Abernathy drawings.)

## KEY TO THE GENERA OF PHLAEOTHIRIPIDAE FOUND IN HAWAII

1. Anterior part of head peculiarly formed (see fig. 227, a), eyes large, subcontiguous behind, first antennal segments concealed from above.....**Macrophthalthrips** Karny.  
Without such a combination of characters..... 2
- 2(1). The long setae at hind prothoracic angles simple at apices.... 3  
The long setae at hind prothoracic angles capitate..... 9
- 3(2). Sides of head (cheeks) coarsely granular or papillate, some granules or warts bearing spines; three distal antennal segments closely united, sometimes appearing to be a single segment .....**Dermothrips** Bagnall.  
Sides of head at most finely granular and without setiferous papules; antennal segment seven always distinctly separated from six ..... 4
- 4(3). Head not much longer than prothorax (fore femora of male greatly enlarged) .....**Nesothrips** Kirkaldy.  
Head conspicuously longer than prothorax..... 5
- 5(4). Sides of head, femora and tibiae with several or many long, stout spines or comparatively long, stout spines..... 6  
Sides of head, femora and tibiae with few or no stout spines, those present fine ..... 7
- 6(5). Antecellar bristles more prominent than postocellars...  
.....**Diceratothrips** Bagnall.  
Postocellar bristles more prominent than antecellars....  
.....**Dichaetothrips** Hood.
- 7(5). Fore tarsi armed with a strongly developed thumb-like tooth (except in *Hoplothrips paumalui*, but that species has most antennal segments dark instead of pale as in our *Liothrips*, and the head is not much longer than broad; the shorter head and pointed mouth cone will separate it from *Rhaebothrips*).....  
.....**Hoplothrips** Amyot and Serville.  
Fore tarsi unarmed ..... 8
- 8(7). Mouth cone sharply pointed.....**Liothrips** Uzel.  
Mouth cone bluntly rounded.....**Rhaebothrips** Karny.
- 9(2). Sides of head (cheeks) with bristle-bearing tubercles or papules .....**Phlaeothrips** Haliday.  
Sides of head without bristles-bearing tubercles.....10
- 10(9). Eighth antennal segment distinctly pedicellate at base (segments three to seven also pedicellate).....  
.....**Polyporothrips** Watson.  
Eighth antennal segment broadly joined at the base to seven and not pedicellate.....11
- 11(10). Head with length of dorsal exposed part to apex of inter-antennal process not as great or only slightly greater than extreme breadth .....12  
Exposed part of head distinctly longer than broad, as much as one-third longer than broad .....13

- 12(11). Third antennal segment cone-shaped or subglobular and but little longer than broad; wings not banded in our species ..... **Haplothrips** Amyot and Serville.  
 Third antennal segment obviously elongate, about twice as long as broad; wings banded in our species.....  
 ..... **Aleurodothrips** Franklin.
- 13(11). Entirely dark species; fore legs armed with a long, strong, projecting tooth on basal tarsal segment and one or two small denticles near apex of each tibia; fore femora normally with a blunt, subbasal tooth on inner margin....  
 ..... **Podothrips** Hood.  
 Species at least partly pale; fore femora and tibiae unarmed; fore tarsus with a comparatively small subapical tooth ..... **Karnyothrips** Watson.

Genus **PHLAEOTHRIPS** Haliday, 1836:441

*Phloeothrips* Burmeister, 1838.

KEY TO THE SPECIES FOUND IN HAWAII

1. Mouth cone not unusually elongate, not extending beyond prosternum ..... **claratibia** Moulton.
2. Mouth cone unusually elongate, reaching about to middle of mesosternum ..... **mauiensis** Moulton.

**Phlaeothrips claratibia** Moulton (fig. 216, a).

*Phloeothrips claratibia* Moulton, 1937:414.

Oahu (type locality: Kipapa).

Immigrant, but not yet recorded elsewhere.

Hostplants: on the leaves of pineapple, *Pritchardia* and *Pandanus*.

**Phlaeothrips mauiensis** Moulton (fig. 219).

*Phloeothrips mauiensis* Moulton, 1928:130.

Oahu, Maui (type locality: Olinda), Hawaii.

Immigrant, but not yet known elsewhere.

Hostplants: *Acacia koa* (under dead bark), *Ipomoea*, *Pittosporum confertiflorum*, *Sophora chrysophylla*.

Genus **LIOTHRIPS** Uzel, 1895

**Liothrips floridensis** (Watson).

*Cryptothrips floridensis* Watson, 1913:145, pl. 6, figs. 1-4.

*Liothrips floridensis* (Watson) Hood, 1918:132.

The camphor thrips.

Oahu.

Immigrant. Described from camphor from Florida. First recorded from the Hawaiian Islands by Swezey in 1939 from specimens collected in Honolulu in 1938.

Hostplant: camphor; infests the buds, killing some and deforming the leaves.

### Genus **POLYPOROTHRIPS** Watson, 1927

#### **Polyporothrips biformis** (Moulton).

*Poecilothrips biformis* Moulton, 1934:501.

*Polyporothrips biformis* (Moulton) Moulton, 1936:187.

Oahu (type locality: Honolulu).

Immigrant (?).

Only females of this species are known, and they may or may not have wings. The type series was taken from a decaying stump.

### Genus **MACROPHTHALMOTHRIPS** Karny, 1922

*Ophthalmothrips* Karny, 1920, not Hood, 1919.

#### **Macrophthalthothrips hawaiiensis** Moulton (figs. 225; 227, a).

*Macrophthalthothrips hawaiiensis* Moulton, 1928:122, pl. 1, fig. 3.

Kauai, Oahu, Maui (type locality: Olinda), Hawaii.

Immigrant, but not yet recorded elsewhere.

Hostplants: *Acacia koa* (under dead bark), *Perottetia sandwicensis*, *Sophora chrysophylla*, *Sapindus saponaria*, *Xylosma hawaiiensis* var. *hillebrandii*.

### Genus **NESOTHRIPS** Kirkaldy, 1907:103

*Oedemothrips* Bagnall, 1910:680. Synonymy and redescription by Bianchi, 1944:31.

This genus is known elsewhere from New Zealand, Australia, Japan and Ceylon.

#### **Nesothrips oahuensis** Kirkaldy (fig. 227, d).

*Nesothrips oahuensis* Kirkaldy, 1907:103. Genotype.

*Oedemothrips laticeps* Bagnall, 1910:680, pl. 17, figs. 6, 10. Genotype of *Oedemothrips*. Synonymy and redescription by Bianchi, 1944:32, pl. 1. The dry, card-mounted type and a slide-mounted cotype female are in the British Museum.

*Nesothrips hawaiiensis*, name cited in error by Bianchi, 1944:31. Bianchi, 1945:279, emended description.

Endemic (?). Oahu (type locality: Mount Tantalus), Molokai, Lanai.  
Hostplant: *Carex wahuensis*.

Genus **DERMOTHrips** Bagnall, 1910:677

This genus has not yet been reported from outside the Hawaiian Islands.

**Dermothrips hawaiiensis** Bagnall (fig. 227, e).

*Dermothrips hawaiiensis* Bagnall, 1910:678, pl. 17, figs. 1, 5. Genotype.

Endemic (?). Kauai, Oahu, Maui, Hawaii.

Hostplant: *Myrsine* (*Suttonia*) (under dead bark).

Both macropterous and brachypterous forms of this species have been found.

The card-mounted holotype male is in the British Museum, as are three slides of cotype females (apterous) and one slide-mounted macropterous female.

Genus **HOPLOTHrips** Amyot and Serville, 1843

*Dolerothrips* Bagnall, 1910:682. Synonymy by Hood, 1915:105.

The situation existing as to the status of the species of this genus is too involved to be clarified in this work. It is next to impossible, if not completely impossible, to straighten out the group without gathering together all of the types and a series of fresh material and making a detailed study of each species.

Bagnall, in *Fauna Hawaiiensis*, originally assigned nine species to *Dolerothrips* and two to *Trichothrips*. These 11 species are now included in *Hoplothrips*, which is a taxonomically difficult assemblage of species. Most or all of Bagnall's material consisted of card-mounted, dried specimens, and six of his 11 species were founded upon unique specimens, some of which were imperfect. In recent years Moulton has added six species to bring the list of Hawaiian *Hoplothrips* to 17. Moulton evidently could not identify Bagnall's species from the literature, and apparently described most of the various species coming to him for identification as new species in an attempt to make a fresh start on the Hawaiian *Hoplothrips*. In doing so, however, it appears that he has redescribed some of Bagnall's species. This, in brief, is an outline of the difficult situation confronting us in our study of local *Hoplothrips*.

Bagnall (1910:683) gave a key to include all but one of his new species of *Dolerothrips* and *Trichothrips* (p. 692). I have recast his key to include all of his 11 species. The new key may aid in separating a collection of *Hoplothrips* into species which, through more detailed study and comparison, might be specifically identified or placed with a group of species or shown *not* to be certain species. The reader should understand that this key has not been tested, and it may prove to be not workable when adequate material is assembled.

## KEY TO THE SPECIES OF HOPLOTHRIPS DESCRIBED BY BAGNALL

1. Head as broad as long or very nearly as broad as long..... 2  
Head longer than broad..... 3
- 2(1). Chestnut brown; posterior ocelli remote from inner margins of eyes; tube four-fifths as long as head and three times as long as breadth at base..... **laticornis** (Bagnall).  
Black; posterior ocelli touching inner margins of eyes; tube less than two-thirds as long as head and only twice as long as breadth of base..... **nigricans** (Bagnall).
- 3(1). All femora yellow..... **flavipes** (Bagnall).  
All femora concolorous with body..... 4
- 4(3). Abdominal bristles abbreviated or obsolete..... 5  
Abdominal bristles well developed..... 6
- 5(4). Abdominal bristles abbreviated (tube short and broad)....  
..... **intermedius** (Bagnall).  
Abdominal bristles obsolete..... **lanaiensis** (Bagnall).
- 6(4). Length 3.5 mm.; cheeks slightly swollen and spinose near posterior third..... **barbatus** (Bagnall).  
Length 1.6–2.5 mm.; cheeks more or less evenly spinose..... 7
- 7(6). Abdomen dark-brown, tube pale reddish-brown, almost as long as head..... **bicolor** (Bagnall).  
Abdomen and tube concolorous; tube distinctly shorter than head..... 8
- 8(7). Tube about twice as long as its basal breadth..... 9  
Tube about three times as long as its basal breadth..... 10
- 9(8). Antennae with basal part of segment three yellowish, remainder dark in color..... **perkinsi** (Bagnall).  
Antennae with parts of segments three to five yellowish....  
..... **dubius** (Bagnall).
- 10(8). Head long and narrow, one and one-half times as long as broad..... **angusticeps** (Bagnall).  
Head only a little longer than broad..... **ovatus** (Bagnall).

The species described by Moulton might be separated by the following key which I have drawn up partly from his descriptions.

## KEY TO THE HAWAIIAN HOPLOTHRIPS DESCRIBED BY MOULTON

1. "A pair of very weak wing retaining spines on abdominal segments three to seven and a single long prominent spine near posterior margin on each side, the regular spines vestigial"..... **hawaiiensis** Moulton.  
Not so, the spines developed and/or with two prominent spines near posterior margin..... 2
- 2(1). Wings clear; fore tarsi unarmed..... **paumalui** Moulton.  
Wings grayish-brown; fore tarsi armed with a tooth..... 3
- 3(2). Outer outline of eyes flattened..... **coprosmae** Moulton.  
Outer outline of eyes obviously convex..... 4
- 4(3). Antennae somewhat more than twice as long as head, segment eight spindle-shaped; tibiae yellow.....  
..... **flavitibia** Moulton.

- Antennae about twice as long as head or less than twice as long as head, segment eight spindle-shaped or not; tibiae brown or brownish ..... 5
- 5(4). Eighth antennal segment spindle-shaped and obviously narrower than seven ..... *mauiensis* Moulton.  
Eighth antennal segment stout, not spindle-shaped, but slightly narrower than seven ..... *swezeyi* Moulton.

**Hoplothrips angusticeps** (Bagnall).

*Dolerothrips angusticeps* Bagnall, 1910:688, pl. 18, figs. 20–22.

*Hoplothrips angusticeps* (Bagnall) Hood, 1915:105.

Endemic. Molokai (type locality: Kalae ?).

The card-mounted type is in the British Museum.

**Hoplothrips barbatus** (Bagnall).

*Dolerothrips barbatus* Bagnall, 1910:683, pl. 18, figs. 11–14.

*Hoplothrips barbatus* (Bagnall) Hood, 1915:105.

Endemic. Hawaii (type locality: Kona, 4,000 feet).

Known only from the unique male type which was found beneath a decaying log. This specimen is mounted on a slide in the British Museum.

**Hoplothrips bicolor** (Bagnall).

*Dolerothrips bicolor* Bagnall, 1910:688, pl. 19, figs. 21–22.

*Hoplothrips bicolor* (Bagnall) Hood, 1915:105.

Endemic. Oahu (type locality: "Kaala Mts., over 2000 ft.").

The dry holotype is mounted on the same card as *Hoplothrips nigricans* ("Trichothrips") in the British Museum.

**Hoplothrips coprosmae** Moulton.

*Hoplothrips coprosmae* Moulton, 1936:186.

Endemic. Kauai, Oahu, Maui, Hawaii (type locality: Nauhi).

Hostplants: *Coprosma* (type series from cracks in stem), *Dodonaea*.

Moulton, in his original description, stated that the head of this species was 1.4 times as long as broad. However, measurements of two of the paratypes reveal that the head is only 1.1 times as long as broad.

**Hoplothrips dubius** (Bagnall).

*Dolerothrips dubius* Bagnall, 1910:691, pl. 19, figs. 23–27.

*Hoplothrips dubius* (Bagnall) Hood, 1915:105.

Endemic. Molokai, Lanai, Hawaii (type locality not designated by Bagnall).  
The card-mounted type is in the British Museum.

**Hoplothrips flavipes** (Bagnall) (figs. 216, b; 219).

*Dolerothrips flavipes* Bagnall, 1910:685, pl. 18, figs. 15-19. Genotype of *Dolerothrips*.

*Hoplothrips flavipes* (Bagnall) Hood, 1915:105.

*Dolerothrips japonicus* Karny, Arkiv für Naturgeschichte, 79A:126, 1913. Synonymy by Hood, 1939:587.

*Trichothrips karnyi major* Hood, 1914:153. Synonymy by Hood, 1939:587.

Maui (type locality: Haleakala).

Immigrant. Known also from Japan and introduced into the United States. See Hood, 1939:587, footnote 5.

Part of the type series was found under dead bark at 5,000 feet, but apparently the type locality is 3,000 feet. A slide marked "Cotype, Haleakala, Maui, 3000 ft., IV, 1894," is in the British Museum as are four other slides.

I am not sure that Hood's synonymy is correct, and this may be an endemic species.

**Hoplothrips flavitibia** Moulton (fig. 227, c).

*Hoplothrips flavitibia* Moulton, 1928:117.

Kauai, Oahu (type locality not designated in the original description), Maui, Hawaii.

Immigrant. Moulton (1939:144) identified material I collected at Tahiti and in the Austral Islands as this species, but the specimens should be checked carefully.

Hostplants: *Acacia koa*, *Aleurites moluccana*, *Auricularia* (an edible fungus), *Eucalyptus*, *Eugenia cumini* (Java plum), *Prosopis*, *Myrsine* (*Suttonia*) (under dead bark and in insect burrows).

**Hoplothrips hawaiiensis** Moulton.

*Hoplothrips hawaiiensis* Moulton, 1936:185.

Endemic. Oahu (type locality: Mount Tantalus), Maui.

Hostplants: *Cibotium menziesii* (in dead fronds), "tree ferns," *Metrosideros*.

**Hoplothrips intermedius** (Bagnall).

*Dolerothrips intermedius* Bagnall, 1910:689, pl. 19, figs. 7-9.

*Hoplothrips intermedius* (Bagnall) Hood, 1915:105.

Endemic. Maui (type locality: Haleakala, 3,000 feet).

The dried type is in the British Museum.



**Hoplothrips lanaiensis** (Bagnall).

*Dolerothrips lanaiensis* Bagnall, 1910:690, pl. 19, figs. 10-16.

*Hoplothrips lanaiensis* (Bagnall) Hood, 1915:105.

Endemic. Molokai, Lanai, Hawaii (type locality not designated in original description).

The card-mounted type is in the British Museum.

**Hoplothrips laticornis** (Bagnall).

*Trichothrips laticornis* Bagnall, 1910:692, pl. 18, figs. 6-10.

*Hoplothrips laticornis* (Bagnall) Moulton, 1928:133.

Endemic. Hawaii (type locality: Kona, 3,000 feet).

Dr. Laing reports that the type has never been traced and that "This was a single female in spirit; it is also a figured species and I suspect that it was never returned to Bagnall by the artist."

**Hoplothrips mauiensis** Moulton (fig. 216, c).

*Hoplothrips mauiensis* Moulton, 1928:119.

Endemic. Oahu, Maui (type locality: Olinda).

Hostplant: *Acacia koa* (under bark).

**Hoplothrips nigricans** (Bagnall).

*Trichothrips nigricans* Bagnall, 1910:693, pl. 18, fig. 23.

*Hoplothrips nigricans* (Bagnall) Moulton, 1928:134.

Endemic. Oahu (type locality: "Kaala Mts., over 2000 ft.").

The type is mounted dry on a card in the British Museum.

**Hoplothrips ovatus** (Bagnall).

*Dolerothrips ovatus* Bagnall, 1910:686, pl. 18, figs. 1-6.

*Hoplothrips ovatus* (Bagnall) Hood, 1915:105.

Endemic. Maui (type locality: Haleakala, 5,000 feet).

The card-mounted type is in the British Museum together with one other slide.

**Hoplothrips paumalui** Moulton.

*Hoplothrips paumalui* Moulton, 1937:412.

Oahu (type locality: Paumalu).

Immigrant (?).

Hostplants: *Emilia sonchifolia*, *Lantana camara*, *Paspalum conjugatum*.

This is the only one of our *Hoplothrips* which has the fore tarsi unarmed and the wings clear.

***Hoplothrips perkinsi* (Bagnall).**

*Dolerothrips perkinsi* Bagnall, 1910:687, pl. 19, figs. 17-20.

*Hoplothrips perkinsi* (Bagnall) Hood, 1915:105.

Endemic. Lanai (type locality: 2,000 feet).

The card-mounted type is in the British Museum.

***Hoplothrips swezeyi* Moulton.**

*Hoplothrips swezeyi* Moulton, 1928:120.

Endemic. Maui (type locality: Olinda).

Hostplants: under dead bark and in dead wood of *Metrosideros*, *Myrsine*, *Pipturus*, *Rubus hawaiiensis*.

GENUS. INCERTAE SEDIS

**Genus *AGNOSTOCHTHONA* Kirkaldy, 1907:102**

This genus has not been recognized in any Hawaiian material collected since its description appeared. The type was probably point-mounted, as was Kirkaldy's type of *Nesothrips*, and it may have been lost or destroyed. Bagnall (1910:694) could not recognize it, and he said that the characters given by Kirkaldy in his description "are much too meagre upon which to erect a genus; in fact as the description now stands the type species may be relegated to any one of several genera, not a single character of generic value is emphasized in the diagnosis. From the short specific description it is clear that the species is not represented in the collection made by Dr. Perkins. As yet we have not had the opportunity of examining Kirkaldy's types; this will be necessary before its true position can be made clear."

In my opinion, *Agnostochthona* may be a synonym of *Hoplothrips*, and its genotype may be a synonym of one of the common species found at the type locality. However, Karny (1921:38) assigned a new species from Java (on *Hevea* rubber) to this genus. It is possible that Karny's species is not congeneric with that of Kirkaldy.

***Agnostochthona alienigera* Kirkaldy.**

*Agnostochthona alienigera* Kirkaldy, 1907:102. Genotype.

Endemic (?). Oahu (type locality: Mount Tantalus).

Habit: found under the bark of a dead tree.

Genus **ALEURODOTHrips** Franklin, 1909**Aleurodothrips fasciapennis** (Franklin) (fig. 227, b).

*Cryptothrips fasciapennis* Franklin, 1908:727, pl. 64, figs. 12, 13.

Oahu.

Immigrant. Widespread; described from the West Indies. First recorded from Hawaii by Moulton (1936:187) from specimens taken from a coconut from Honolulu intercepted in quarantine at San Francisco.

Hosts: predaceous on aleurodids, crawlers of coccids, including *Diaspis echinocacti* on *Epiphyllum*, and probably on aphids; also found on coconut, *Ficus bengalensis*.

Genus **KARNYOTHrips** Watson, 1923:70

*Karnyia* Watson, 1922, preoccupied.

Some workers refer this group to *Haplothrips*, as a subgenus.

## KEY TO THE SPECIES FOUND IN HAWAII

1. Conspicuously bicolored, most of abdomen obviously paler than apex or head and thorax.....**melaleuca** (Bagnall).  
Dark brown, not distinctly bicolored..... 2
2. Antennal segments three and four rather similar in shape, three narrowed from near apex to base and subtriangular in outline .....**flavipes** (Jones).  
Third and fourth antennal segments conspicuously different in shape, three very broad and subtruncate at base, more subparallel-sided than subtriangular in shape.....**doliicornis** Bianchi.

**Karnyothrips doliicornis** Bianchi.

*Karnyothrips doliicornis* Bianchi, 1946:510, pl. 30, figs. A, B, C.

Hawaii (type locality: Makaopuhi, 2,870 feet).

Immigrant (?).

Hostplants: *Metrosideros*, *Myoporum sandwicense*, *Myrsine lessertiana*, *Sadleria*, *Sophora chrysophylla*.

**Karnyothrips flavipes** (Jones).

*Anthothrips flavipes* Jones, 1912:18, pl. 5, figs. 5-7.

*Haplothrips* (*Karnyothrips*) *flavipes* (Jones), of authors.

Oahu, Hawaii.

Immigrant. Widespread. First recorded from the Hawaiian Islands by Moulton (1936:187) from specimens collected on Oahu by Swezey in 1933 and 1934.

Hostplants: *Acacia koa*, *Coprosma*, *Euphorbia*, *Lantana* (blossoms), *Macaranga*, *Metrosideros*, *Mezoneurum kauaiense*, *Myoporum sandwicense*, *Myrsine lessertiana*. It is a predator. Bianchi (1945:279) found them in old oothecae of the mantid *Tenodera angustipennis*.

**Karnyothrips melaleuca** (Bagnall).

*Hindsiana melaleuca* Bagnall, 1911:61.

*Dolerothrips carteri* Watson, a manuscript name and misidentification in Ito and Carter, 1932:44.

Kauai, Oahu, Hawaii.

Immigrant. Widespread; described from a unique specimen taken from a hot-house crucifer at Copenhagen. First recorded from Hawaii by Moulton (1934:502) from specimens collected on Oahu by Carter and Illingworth.

Hostplants: *Bothriospermum tenellum*, *Cibotium chamissoi*, *Coronopus didymus* (*Senebiera didyma*), *Digitaria sanguinalis*, *Emilia* species, *Heimerliodendron brunonianum*, Job's tears, pineapple, *Pittosporum confertiflorum*, sugarcane, *Tricholaena repens* (*rosea*). Evidently a predaceous species which feeds upon "red spiders."

Genus **PODOTHRIPS** Hood, 1913

Subgenus **Kentronothrips** (Moulton, 1928:126) Priesner, 1938:68

**Podothrips (Kentronothrips) lucasseni** (Krüger) (figs. 225, 228).

*Phloeothrips Lucasseni* Krüger, 1890:105, pl. 3B, figs. 8-9.

*Kentronothrips hawaiiensis* Moulton, 1928:126, pl. 1, figs. 4, 5. 1940:268. Genotype of *Kentronothrips*. For detailed redescription and synonymy, see Priesner, 1938:68, figs. 1-2.

Kauai, Oahu, Hawaii.

Immigrant. Widespread in the Indo-Pacific regions. First recorded from the Territory by Moulton (1928:126, as *Kentronothrips hawaiiensis*) from specimens intercepted in quarantine in San Francisco in 1909 on sugarcane from Honolulu and from material collected by Swezey in 1927.

Hostplants: sugarcane (common behind leaf sheaths), sour grass (*Trichachne insularis* [*Valota insularis*]).

A predator on the stalk mite, *Tarsonemus spinipes* Hirst.

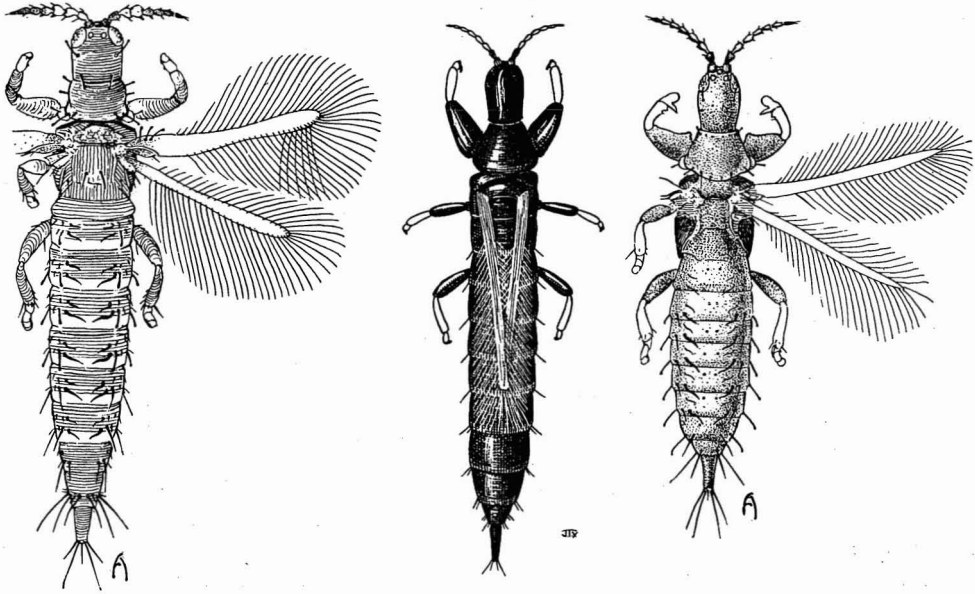


Figure 228—*Haplothrips* (*Haplothrips*) *gowdeyi* (Franklin), left (wings reconstructed); *Podothrips* (*Kentronothrips*) *lucasseni* (Krüger), middle and right (the middle figure is of a fresh example, the one on the right is from a slide mount). (Middle figure after Williams, 1931; others by Abernathy; not to same scale.)

Genus **HAPLOTHRIPS** Amyot and Serville, 1843

It is unfortunate that the authors of this genus should have also chosen to erect so similar a name as *Hoplothrips*, because considerable confusion occurs in the use of the names.

KEY TO THE SPECIES OF HAPLOTHRIPS FOUND IN HAWAII

1. Fore tarsi armed with one or two small claws; dark-colored species ..... 2
- Fore tarsi evidently unarmed; body at least partly pale..... 5
- 2(1). Large setae behind middle of prothorax with blunt or expanded tips ..... 3
- These setae fine and with slender sharp tips..... 4
- 3(2). Third antennal segment with three sense cones, one of which is on the inner (anterior) face of the segment (thus a sense cone is visible on both the inner and outer sides of the segment); large postero-lateral dorsal abdominal spines dark ..... **gowdeyi** (Franklin).
- Third antennal segment with only one sense cone, and that on the outer (posterior) face (thus only one sense cone is visible in the same plane of focus); large postero-lateral dorsal abdominal spines pale..... **fusca** Moulton.

- 4(2). Antero-marginal setae of pronotum all minute. . . . **rosai** Bianchi.  
Outer antero-marginal setae of pronotum as long as antero-  
angulars . . . . . **davisi** Bianchi.
- 5(1). Body conspicuously bicolored; head, thorax and abdominal  
segments eight to ten dark, remainder of abdomen pale;  
antennae with segments three to six paler than others. . .  
. . . . . **sakimurai** Moulton.  
Body not strikingly bicolored; antennal segments two and  
three only pale . . . . . **williamsi** Moulton.

Subgenus **Haplothrips** Amyot and Serville

**Haplothrips (Haplothrips) davisi** Bianchi.

*Haplothrips davisi* Bianchi, 1946:503, pl. 29, fig. D; pl. 30, fig. D.

Endemic (?). Hawaii (type locality: Mauna Loa truck trail, 6,500 feet).

Hostplants: *Acacia koa*, *Metrosideros*, *Pipturus*, *Sophora chrysophylla*. Found on leaves and dead branches.

Bianchi (1946:506) says, "from other species found in Hawaii it can be separated easily by its long pointed setae, of which only the anteroangulars and anteromarginals on the pronotum are likely to be, but are not always, slightly expanded at the end."

**Haplothrips (Haplothrips) fusca** Moulton.

*Haplothrips (Haplothrips) fusca* Moulton, 1928:124.

Oahu (type locality: Fort Kamehameha), Molokai.

Immigrant, but not yet known elsewhere.

Hostplants: *Batis maritima*, *Cladium angustifolium* (sedge).

**Haplothrips (Haplothrips) gowdeyi** (Franklin) (fig. 228).

*Anthothrips gowdeyi* Franklin, 1908:724, pl. 63, fig. 8; pl. 64, figs. 15, 16; pl. 65, fig. 23.

*Anthothrips usitatus* Bagnall, 1910:695, pl. 17, figs. 16-17 (type series from Hilo grass at Kona, Hawaii, 2,000 feet, collected by Perkins in 1892). Synonymy by Moulton, 1934:502. Bagnall's type series, a slide containing the male and female types, a slide containing a male and female cotype and a slide containing two cotype females are in the British Museum.

The black flower thrips.

Kauai, Oahu, Molokai, Lanai, Maui, Hawaii, Midway.

Immigrant. Cosmopolitan. First recorded from the Hawaiian Islands by Bagnall (1910:695, as *Anthothrips usitatus*) from specimens taken by Perkins on Hawaii in 1892.

Hostplants: This species is commonly found in clusters of flowers. *Acacia farnesiana*, *Ageratum conyzoides*, alfalfa, *Amaranthus hybridus*, *Amaranthus viridis* (*gracilis*) (misidentified as *A. retroflexus*), *Argemone alba* var. *glauca* (prickly poppy), *Aster*, *Bidens pilosa*, *Bothriospermum tenellum*, *Brassica* ("shirona"), *Buddleia japonica*, *Cajanus cajan*, canna, carrot, *Cassia leschenaultiana* (misidentified as *mimosoides*), *Cassia occidentalis*, *Cenchrus echinatus*, *Chenopodium album* var. *candicans*, *Chloris inflata* (*paraguayensis*), *Chloris radiata*, cockscomb, *Commelina diffusa* (*nudiflora*), *Coronopus didymus* (*Senebiera didyma*), cotton, *Crotalaria juncea*, *Crotalaria mucronata* (*saltiana*), *Cucumis dipsaceus*, *Cyperus rotundus*, dandelion (*Taraxacum officinale*), *Digitaria pruriens*, *Digitaria sanguinalis* (*Syntherisma sanguinalis*), *Dioclea violacea*, *Echinochloa crus-galli*, eggplant, *Emilia coccinea*, *Emilia sonchifolia*, *Eragrostis cilianensis*, *Eragrostis variabilis*, *Erigeron albidus*, *Erigeron canadensis*, *Euphorbia geniculata*, *Gaillardia pulchella*, *Hippobroma longiflora* (*Isotoma longiflora*), *Hymenocallis declinata*, *Hypochaeris radicata*, *Ipomoea cairica*, *Ipomoea pes-caprae*, *Lantana camara*, lettuce, *Leucaena glauca*, *Malva*, *Mimosa pudica*, *Mirabilis jalapa*, onion, *Operculina aegyptia* (*Ipomoea pentaphylla*), *Panicum purpurascens* (*bardinode*), *Panicum torridum*, *Paspalum conjugatum*, *Paspalum dilatatum*, *Paspalum orbiculare*, *Phaseolus lathyroides*, *Phytolacca octandra* (misidentified as *acinosa*), pineapple, *Plantago lanceolata*, *Plantago major*, *Pluchea indica*, *Portulaca oleracea*, *Prosopis chilensis*, *Raphanus sativus*, *Richardsia scabra* (*Richardsonia scabra*), *Salvia leucantha*, *Setaria geniculata*, *Setaria verticillata*, *Solanum nodiflorum*, *Stachys arvensis*, *Stachytarpheta cayennensis* (*dichotoma*), *Tephrosia purpurea* (*piscatoria*), *Tithonia rotundifolia*, tomato, *Tribulus cistoides* ("nohii"), *Trichachne insularis*, *Tricholaena repens* (*rosea*), *Trisetum glomeratum*, *Verbena litoralis* (misidentified as *bonariensis*), *Verbesina encelioides*, *Vernonia cinerea*, *Waltheria americana*, *Zinnia pauciflora*.

#### **Haplothrips (Haplothrips) rosai** Bianchi.

*Haplothrips rosai* Bianchi, 1946:506, pl. 29, figs. A, B, C; pl. 30, fig. E.

Endemic (?). Hawaii (type locality: Makaopuhi, 2,870 feet).

Hostplants: *Metrosideros*, *Myrsine*, *Sadleria*, *Vaccinium*. Found on leaves, dead branches and fern fronds.

#### Subgenus **Hindsiana** Karny, 1910

#### **Haplothrips (Hindsiana) sakimurai** Moulton.

*Haplothrips (Hindsiana) sakimurai* Moulton, 1937:412.

Endemic (?). Kauai, Oahu (type locality: Kipapa), Hawaii.

Hostplants: *Cyperus rotundus* (nutgrass), *Emilia sonchifolia*, *Myoporum sandwicense*.

**Haplothrips (Hindsiana) williamsi** Moulton.

*Haplothrips (Hindsiana) williamsi* Moulton, 1934:502.

Endemic (?). Hawaii (type locality: Mount Hualalai).

Hostplants: under dead bark of *Diospyros (Maba)*, *Rubus hawaiiensis*, *Myrsine lessertiana*.

**Genus RHAEBOTHRIPS** Karny, 1913**Rhaebothrips major** Bagnall (fig. 223, A-C).

*Rhaebothrips major* Bagnall, 1928:75. Bianchi, 1945:280, pl. 17, figs. A, B, C; redescription.

Oahu.

Immigrant. Described from Samoa and known from Fiji. First reported from the Hawaiian Islands by Bianchi in 1945 from specimens collected in Honolulu in 1944.

Hostplants: it has been found in colonies in the hollow stems of *Merremia (Ipomoea) tuberosa* (wood rose), papaya and pigeon pea.

**Genus DICERATOTHRIPS** Bagnall, 1908**Diceratothrips brevicornis** Bagnall.

*Diceratothrips brevicornis* Bagnall, 1910:697, pl. 18, figs. 1-3. Moulton, 1936:187.

Oahu (type locality: Kawaihoa Gulch mountains).

Immigrant (?).

Hostplant: *Osteomeles* (under bark).

This species was described from an unique female (which is mounted dry on a card in the British Museum). The only other record of the species is that of Moulton (1936:187), who recorded a specimen found under *Osteomeles* bark in Manoa Valley, Oahu, September, 1929, by Swezey. This species remains unknown to resident thysanopterists in Honolulu, and there seems to be some doubt that the species is distinct from *Dichaetothrips setidens* (Moulton). In answer to my query as to how the species differed, Moulton, in 1944, said that he felt that they were distinct forms. He also stated that "The principal character separating the two genera... is the development of the ante-ocellar and post-ocellar setae. In *Diceratothrips* the ante-ocellars are usually strongly developed while in *Dichaetothrips* the post-ocellars are the most prominent.... In *Dichaetothrips* the post-ocellars are sometimes almost as long as the postoculars and quite prominent while the ante-ocellars are very small or wanting... but at best it is sometimes almost impossible to distinguish between the two genera."



Genus **DICHAETOTHRIPS** Hood, 1914

In addition to the following species, Bianchi has specimens of another species from Oahu which is as yet undetermined.

## KEY TO THE SPECIES FOUND IN HAWAII

1. Wings comparatively clear, not clouded.....**claripennis** Moulton.
2. Wings infusate, with dark vittae.....**setidens** (Moulton).

**Dichaetothrips claripennis** Moulton.

*Dichaetothrips claripennis* Moulton, 1934:503.

Oahu (type locality: Honolulu).

Immigrant, but not yet known elsewhere.

Described from an unique specimen found on a laboratory table at the Hawaiian Sugar Planters' Association Experiment Station by Williams in 1930. Small colonies have been found in dry hollow twigs of papaya and pigeon pea.

**Dichaetothrips setidens** (Moulton).

*Mesothrips setidens* Moulton, 1928:129.

*Cryptothrips niger* Moulton and Steinweden, 1933:165, fig. 1, d-f.

*Dichaetothrips niger* (Moulton and Steinweden) Moulton, 1939:147. Synonymy by Moulton, 1944:308.

Kauai, Oahu (type locality: Manoa Valley, Honolulu).

Immigrant. I have collected this species at Oneata, Lau, Fiji; South Marutea, Tuamotu Archipelago; and Mangareva, Gambier Islands. It is also known from the Marquesas Islands.

Hostplants: *Aleurites*, *Blechnum*, *Casuarina*, guava, *Pteralyxia*, *Ricinus*.

This is our largest thrips. Some slide-mounted specimens measure 4 mm. in length. It is common in dead wood, in dried fruits, under bark and similar places and is widespread. Sakimura, in Sakimura and Krauss (1945:324-325), describes the male. Although these authors say that their collection is the second from the Hawaiian Islands, this species has long been known to some of us as a common insect of Oahu at least. See the discussion under *Diceratothrips*.

Superfamily **UROTHRIPOIDEA** Hood, 1915:59

Suborder *Polystigmata* Bagnall, 1912.

This superfamily contains only one family.

## Family UROTHRIPIDAE Bagnall, 1909

## KEY TO THE GENERA FOUND IN HAWAII

1. Vertex of head not strongly produced. . . . **Stephanothrips** Trybom.
2. Vertex of head conical, produced far distad of eyes and insertions of antennae . . . . . **Conocephalothrips** Bianchi.

Genus **CONOCEPHALOTHRIPS** Bianchi, 1946:499

This monotypic genus is presumed to be endemic.

**Conocephalothrips tricolor** Bianchi.

*Conocephalothrips tricolor* Bianchi, 1946:500, pl. 28, figs. A, B, C.

Endemic. Oahu (type locality: Mount Kaala).

Hostplant: *Broussaisia arguta* (found on the leaves).

Genus **STEPHANOTHRIPS** Trybom, 1913**Stephanothrips occidentalis** Hood and Williams.

*Stephanothrips occidentalis* Hood and Williams, 1932:69.

Oahu.

Immigrant. Described from St. Croix and Trinidad. First recorded from the Hawaiian Islands by Moulton (1934:503) from a specimen taken at Paumalu, Oahu, by Sakimura in 1930.

Hostplant: *Paspalum orbiculare*.

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